# JOURNAL

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## OF

# SUGAR BEET TECHNOLOGISTS

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**Executive Committee, American Society of Sugar Beet Technologists, Biennium 1960-61**

**Left to right: Secretary-Treasurer, James H. Fischer, Beet Sugar Development Foundation, Fort Collins, Colorado; Immediate Past President, Harvey P. H. Johnson, American Crystal Sugar Company, Denver, Colorado; Vice President, J. C. Keane, Utah-Idaho Sugar Company, Salt Lake City, Utah; President, Dewey Stewart, Sugar Beet Section, U. S. Department of Agriculture, Agricultural Research Service, Beltsville, Maryland.**

# President's Message[1]

HARVEY P. H. JOHNSON[2]

Members of the American Society of Sugar Beet Technologists and honored guests.

I believe this would be an appropriate time for the members of the Society to congratulate themselves upon the fact that this promises to be the largest gathering at a general meeting throughout our 25-year history. Registration, which began last evening, indicates that more than 500 are in attendance representing nearly every state west of the Mississippi and a goodly number of states east of that historic geographical dividing line. I am told there are about 30 states represented. In addition, we have with us friends from countries other than our own—Canada, Great Britain, West Germany, Chile, Japan and Poland. To these good people we bid welcome and trust that their stay with us will be most pleasant. There are, too, with us, in addition to those directly affiliated with the beet sugar industry, representatives of equipment and machinery manufacturers, from chemical companies, and other concerns upon whom we rely for a multitude of supplies and services. Our welcome to these gentlemen.

A common purpose has brought all of us here—to exchange ideas and information on beet sugar production with all its varied facets, and to learn of new horizons, new challenges which confront us, and the steps we are taking to meet those challenges.

New vistas are opening before us every day, and it was both the thrill of observing these and conjuring with the future that gave impetus to the formation of this Society a quarter-century ago when only a handful of men met for what they called a "round-table" discussion of topics of mutual interest.

Thus we are, in effect, here today celebrating our Silver Anniversary—the Silver Anniversary of a phase of agrarian reform, American style.

We are going to talk of research—of the tools we have used, new tools that our scientists are developing, of our successes—and surely some disappointments. The many papers which will be presented before our ultimate adjournment represent long periods of preparation. The things which will be reported in these papers represent even longer periods of earnest and devoted effort and painstaking study.

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[1] Presented at the 11th Biennial Meeting, American Society of Sugar Beet Technologists, Salt Lake City, Utah, February 2, 1960.

[2] General Agriculturist, American Crystal Sugar Company, Denver, Colorado.

And, as I mentioned, not all the results to be reported will bring forth encouraging answers, for that is part of the very nature of the work in which we are engaged.

I am reminded that once a youthful and impatient young assistant asked Thomas A. Edison:

"Don't you get terribly discouraged after these thousands of failures knowing that all our research has been utterly in vain?"

And Mr. Edison replied, "Our research has not been in vain, for there is always value in finding out what will not work."

Research has become basic to human progress. In a recent national magazine it was reported that currently we are spending approximately 13 billion dollars annually in this country for research and development. It was further stated that we will probably make an investment in planned growth through research and development of no less than 150 billion dollars in the decade of the 1960's, or an average of 15 billion dollars per annum.

The scope of research in our own field is amply testified to by this meeting alone where we are gathered from many places to exchange information in no less than six broad categories and by means of some 150 separate papers on an almost unlimited variety of specific subjects.

Agricultural research today calls upon the combined efforts of a variety of trained specialists in numerous fields of knowledge such as organic, physical, analytical and biological chemistry. We rely upon engineers, chemists, entomologists, bacteriologists, plant pathologists, plant physiologists, agronomists, nematologists, plant breeders, geneticists, soil scientists and all manner of biologists. We have representatives of all these fields at this meeting.

The joint efforts of these and related workers are brought to bear upon the development of a better agriculture. While the costs sometimes appear to be high, the dividends from a well-organized and operated program are virtually unlimited and have become essential to the very existence of agriculture.

For any one person to attempt to summarize a conference such as this would be both brash and absurd—certainly to do so before sessions were even well under way would be a virtual impossibility. Yet, there would seem a place for briefly highlighting certain phases of these meetings on which we are now about to embark.

One of the primary interests of our industry for the past quarter-century has been mechanization — mechanization in growing the crop and mechanization in extracting sugar from the beet once it has been delivered to the mill. Much progress has come. Just 30 years ago, Colorado surveys, for example, showed that it required an even one-hundred man-hours to produce and harvest an acre of sugar beets, which even then represented no little improvement over earlier years. By 1948, this 100 hours had been cut to 60 man-hours. And today there are growers who tell us that their performance is less than one-half the 1948 average and they think there's no doubt they'll cut that even more and very soon.

And what has happened with sugar beet yields during this last twenty-five year period since the organization of the Society? Many areas report that yields have doubled. The national average, however, shows just about a 60 percent increase in yields, which becomes an even more imposing figure when one considers that this is a period during which new production areas came into being, some of which are not aided by irrigation.

But a most startling, and encouraging, statistic is this: In just 25 years total sugar production is up 90 percent on only 10 percent more acreage.

What has happened in the mills during this time? A check of the average daily slice in mills owned by two of our major processing companies showed that in just the 25 years since our Society was born, daily slicing per mill has increased 83 percent.

These are accomplishments which provide a true measure of the value and achievements of research, for research paved the way for most of the gains I have described in the statistics I have presented. This is the surest way, too, for us to catch some of the drama in research, where methods and techniques frequently appear to the untrained eye to encompass a particularly unglamorous realm of activity. To the researcher, the great drama is there before him as he delves behind previously unopened doors where man has never looked before.

Less than 15 years ago, practically all factory processing stations were operating on a batch basis, but today we find that all modern mills have continuous diffusers, continuous carbonation, automatic or drum-type filters and some have continuous crystallizers. Continuous centrifugals are being developed.

A gas-fired lime kiln, about which we will have a paper presented at these meetings, is now a reality and has been successfully operated for the past two seasons.

Ion exchange investigations have unveiled new possibilities in juice purification and, with new resin development, should within the foreseeable future be in a position for incorporation into factory operations.

At its Carlton plant, the Holly Sugar Corporation is taking a step which is being closely followed by the industry and with deep interest. Perhaps some of you are not familiar with this project which, briefly, we understand amounts to construction of another beet end of a house through the evaporators; and instead of proceeding from there as is now considered normal, they will store thick juice in a tank farm, thus allowing the sugar end of the present plant to be operated a greater part of the year. This plan will also, of course, allow them to process beets at nearer their optimum and greatly extend the production of the sugar end of the plant with resulting economies, longer use of equipment and greater sugar storage.

It is generally recognized that all plants must be further automated, and this can be accomplished in some cases through re-design of present equipment. We understand that there has been a demonstration of the physical possibilities in a beet sugar plant in England. Perhaps what was done there constitutes a more ambitious undertaking than any one privately-owned company would be able to tackle. But we are informed that certain technical personnel of the armed forces in England were not needed for a time, so these people were, so to speak, turned loose in a sugar plant and they have come up with an almost complete automation. From across this ocean span can and no doubt will come technical information which will be applied either in part or its entirety to sugar beet processing plants in this country.

A changing sugar market which demands ever greater stocks of bulk granulated or liquid sugar also is influencing the direction of our factory improvements and changes, all pointing to a streamlining of operations.

Automation, indeed, is helping our operating efficiency, but what of our extraction efficiency? Here progress has been more difficult to evaluate. To improve this the only answer is different and better processes arrived at by a vast program of research entered into and carried on by all beet sugar companies as a joint venture.

These things, then, are some of the subjects to be more fully explored in the ensuing Section E. of our meetings.

Agriculturally, the mechanization of the steps in production of the sugar beet crop still tops the list of our investigations and

development. Notably absent this year, in contrast to previous meetings, are papers on techniques and results of mechanical thinning. Often at past meetings in recent years, the best attended sessions were those which dealt with this subject. Why the change? Well, I believe it would be erroneous to think that interest has died. The fact seems to be that the general techniques adopted are now considered too commonplace for further discussion. We have entered a phase in which we are gathering experience in actual practice—a settling down period on known techniques. While it is probable that no one person may accurately know how widely machines are used in thinning operations today, a guess of 60 percent, or even more, would probably not be too far amiss.

If there be a bottleneck to further utilization of machines in the spring thinning program, it undoubtedly is in better weed elimination. There will be a number of papers presented at this meeting reporting results with materials such as Eptam, Endothal, and TCA, to mention just a few. Knowing what materials are available is not enough. We must know precisely how to use them, whether these chemicals must be applied before or after emergence of the beet seedlings, and the toxic effects they have upon the beets themselves.

We are to hear reports on new formulations of the more promising weed control chemicals. It will be suggested that granular herbicides for band application offers promise in improving effectiveness and reducing costs.

Recently, there has been much hue and cry concerning use of chemicals with certain other crops. Researchers with sugar beets have not been unaware of such possibilities and some time ago undertook studies to ascertain residual effects of weed chemicals. And in the plant breeding approach, at least one company has embarked upon a program to determine whether certain sugar beet strains might be more tolerant to one herbicide, Endothal, than were others. This, of course, is an effort to eliminate one of the chief pitfalls of chemical weed control, that of injuring or unduly delaying growth of the sugar beet plant. Early results of the study offer encouragement.

While chemical controls offer much promise, we cannot afford to lose sight of the values of mechanical methods. There has been wide acceptance of weeding tools used across the row and over the row, even though some of these had formerly been considered too severe. Admittedly, it takes a lot of sheer guts to apply weeding machinery seemingly indiscriminately across the row both before and after the young beet seedlings emerge.

Yet we find that such practices are enthusiastically employed on thousands of acres nowadays. Company magazines are devoting increasing space to reporting on such methods and rightly so, in my personal estimation, because I feel that here is an opportunity for labor savings which will pay inestimable returns.

We also know that mechanization is not simply a matter of inventing a new device. There are inter-related problems which must be solved before an overall new technique is successful. An example of this is provided in the area of seed processing prior to drilling. We shall hear papers dealing with methods to obtain uniform sizing of seed so that the new precision drills may perform more effectively. Segmentation and decortication of seed have been commonplace for a number of years, but now we have monogerm and a new problem. The monogerm seed is somewhat flat, rather than a ball, which poses a new problem for our agricultural engineers in developing drills. Other improvements are being made to drills to obtain more uniform spacing of the single germ seed units as well as improving soil environment in which the seed unit is placed.

Akin to all this are the fungicide and insecticide additions to the seed which chemical companies are constantly developing and revealing to us. Again with such new development, testing and re-testing is demanded and results of such tests are to be reported here, revealing that some of these new materials have proven to be selective in the disease they will control.

Another field in which much work is proceeding is that of physiology. It is necessary that we gather as much basic information on the physiology of the sugar beet as we can, else we shall find ourselves more or less stumbling in the dark and unnecessarily complicating our efforts. We want to know, for example, why a particular hybrid that seems to be satisfactory in all agronomic characteristics and is highly acceptable so far as sucrose content is concerned, lacks good processing qualities. One research station tackled this problem of purity through investigation of promising new monogerms. The wide array of results obtained is of interest. In commercial processing, agronomic, weather and climatic variances have long been known to have effect upon purity, but now comes a revealing study that warns us care must be taken in developing new varieties, also.

Still in this general realm, there are to be three papers presented on an intriguing subject dealing with a chemical known by number as FW-450, which has been tested as a gametocide. How does this chemical affect the physiology of pollen produc-

tion? The answer is being sought with the hope that we may find a chemical that would do a better job of preventing the functioning of the male gamete without affecting the female gamete. If this could be done by chemical means, almost any hybrid combination could be obtained, with the result that the plant breeder could save space, energy and labor which is now necessary to carry along cytoplasmic male sterile equivalents.

Much still remains to be learned concerning the various factors which affect reproduction in sugar beets, and we have all grown somewhat familiar with investigations of the role of gibberellic acid in this field. Some have explored the use of gibberellic acid in hastening bolting of otherwise slow-bolting varieties in seed production. Others have studied the possibilities of obtaining better root growth in commercial varieties, to increase the weight, purity and sucrose content. These are challenging studies which are not always successful, but nonetheless intriguing at the outset.

And we still are not able to assign definite values to the effects of temperature or light or to the interaction of these two factors in seed production, but there are scientists painstakingly pursuing these answers.

In the field of plant breeding and genetics, increasing attention is being focused on evaluation of more efficient breeding methods. Major emphasis currently is upon development of superior monogerm varieties, some of which already compare very favorably with the best multigerm varieties in yield, quality and disease resistance.

The rapid increase in commercial production of monogerm varieties indicates the success thus far achieved. In just three years—from 1958 through 1960—production of monogerm beet seed for commercial planting has increased from approximately 20 percent to 65 percent of the total production in this country's two leading sugar beet seed producing areas.

Today's commercial monogerm varieties are being produced by two principal methods, namely (1) backcrossing, and (2) cytoplasmic male sterility. These two terms are destined to be used so frequently in years to come that soon they will become common phrases in the language of sugar beet agriculturalists. This being true, it might be well to take a moment briefly to describe these breeding techniques. To the present novice it might make the many papers presented on these subjects more meaningful.

The primary objective of the back-cross method as used by the sugar beet breeder is to transfer the valuable character—

monogermness—into an otherwise desirable variety that lacks this character. The first cross is made between the monogerm variety and the desirable multigerm variety. All of the offspring are multigerm. These offspring are allowed to cross-pollinate and their offspring are made up of both multigerm and monogerm plants. Then only the monogerm offspring is saved and tested for favorable characteristics. The best of these are again crossed to the parental multigerm strain and the cycle I have just described is again completed. At any step in this backcross program, an improved multigerm variety may be substituted as a parent.

After the original cross, the selected monogerm is 50% like the multigerm parent and in each cycle after the original cross, the selected monogerm becomes progressively more like the multigerm parent in all respects except that it still remains a monogerm. The percentage of similarity to the multigerm is, in succeeding crosses (1) 75%, (2) 82.5%, (3) 93.75%, (4) 96.82% and (5) 98.4%. Usually, five or six cycles of backcrossing are practiced to transfer a characteristic such as monogermness into a commercially acceptable variety. Some plant breeders now suggest that fewer backcrosses may be sufficient as the parent monogerm is improved.

The second method, cytoplasmic male sterility, is more difficult to understand. It is a relatively new tool to the plant breeder. As the name implies the inheritance is dependent upon the cytoplasm, or on objects contained in it. This is different from most other characteristics where inheritance is based upon entities carried on or in the chromosomes. The effect of cytoplasmic male sterility is to make the sugar beet male sterile, or female only. This characteristic, by appropriate procedure, can be transmitted to a monogerm selection of sugar beets. The then female monogerm can be crossed with a commercial or highly desirable multigerm. The seed formed on the male sterile monogerm is all monogerm. It also carries a portion of the desirable characteristics of the multigerm parent. Only the seed from the male sterile monogerm plants is harvested and used as commercial seed, if complete monogermness is desired.

To be sure, there are many complexities in these two breeding methods that I have not attempted to discuss, but as more and more information is obtained, these complexities are being simplified.

Polyploidy is another broad field of interest to the plant breeder and geneticist, and we are to hear five papers on early experimental work in this field. Most of the processing com-

panies having research facilities already have work under way on polyploidy, and many have employed special technicians to hasten research in this promising area which now is in early commercial use in Europe. Although plant breeders have barely scratched the surface in this field of endeavor, there already is promise of increased yields, better quality, increased disease resistance and larger seed size through use of this valuable tool.

What is polyploidy? In the very simplest of explanation, it is the multiplication of inheritance carrying chromosomes by the addition of a chemical called colchicine to the sugar beet seed or young seedling. It is this multiplying effect of desirable traits that seemingly gives rise to the promise this breeding technique affords. It is an exacting procedure, one that must be carried out with a high degree of skill and know-how if its full value is to be attained.

Much more will be heard about polyploidy in sugar beet breeding circles in future years as use of this tool increases and knowledge enlarges.

Many of the papers to be presented in the Genetics and Variety Improvement Section will deal with procedures and techniques that are valuable to plant breeders only. In title and subject matter, these papers may seem utterly incomprehensible to the layman, yet to the geneticist and plant breeder, they represent an opportunity to exchange with fellow researchers in these fields case histories of pitfalls which may be present and how to avoid them.

Turning to another general topic of wide interest to be covered in Section C., or Entomology and Plant Pathology, here will be presented new basic information about the organisms which are responsible for the classic and most prevalent disease problems in sugar beet production — virus yellows, curly-top, mosaic, leaf spot, root rot and others.

Through increased knowledge of the organisms involved in these diseases, the plant breeders are becoming better equipped to develop new disease-resistant varieties. Chemical companies are working on some of these problems too, and seem constantly to be producing new chemicals to control diseases and combat insects and other pests found in the production of sugar beets. These new products must be, of course, tested for effectiveness in varying rates.

There has been an intensified study of the habits and control of the lowly nematode during the past five years which has unearthed evidence that this little rascal may find it more difficult to be the troublesome nuisance he has been in the past.

Here again the plant breeder is on the attack, making crosses which may be more tolerant to or free from nematode onslaughts. Some of these crosses are being made with wild forms of the sugar beet family.

One other problem of which we are to hear a good bit at these meetings, and which is of grave concern to all of us interested in the steady increase of beet sugar supply for the American consumer is that which we may call quality control, for want of a better term. This problem may stem from many sources or factors, but the one control which seems presently available to us is the proper use of commercial fertilizer in growing our sugar beet crop. More specifically, one might say the proper use of nitrogen-carrying commercial fertilizer.

Now, no one is suggesting that this important element—nitrogen—should not be used in the production of sugar beets. As a matter of fact, much urging has been used in the past to convince growers of its value in producing greater tonnages.

However, we seem to be confronted with the old idea that if a little is good, a lot is better, which may be at least partially true, up to a point. But the fact is that nitrogen use is on the verge of getting out of hand. Too much nitrogen is bad, having a very adverse effect on sugar content, plus reducing percent of extraction at the mill. We are confronted with a snowball which must not be allowed to roll and grow bigger. On the contrary, it must be permitted to melt down a bit to return us to saner levels of application.

Who is to blame, if we are letting this business of nitrogen use get out of hand? Perhaps no one in particular—perhaps all of us. Nitrogen manifests itself so beautifully in increased foliage growth that it is only human to go overboard. It is becoming the popular way to increase farm productivity with every crop in the rotation being fed more and more of it. Recently, a farm paper carried a headline reading, "The Nitrogen Revolution," beneath which was a story pointing out that commercial nitrogen output has almost doubled in the last 15-year period, and that it now almost equals the combined output of phosphate and potash. The article further stated that yields have been driven up to heights unheard of a few years ago, with an accompanying rocketing of profits. The story told how some Nebraska farmers on irrigated land now are using as much as 320 pounds of nitrogen per acre per year and from this are obtaining corn yields of 150 to 200 bushels per acre.

From Georgia and South Carolina have come glowing reports of high yields of straight coastal Bermuda grass and better

quality. So well might the sugar beet growers be influenced by reading such articles. But this does not alter the fact that what may happen with some crops does not necessarily happen to sugar beets. We know better. Nitrogen is not a part of the chemical formula that is sugar. Only carbon, hydrogen and oxygen are found in sucrose. The presence of excessive nitrogen—called harmful nitrogens—tends only to make sugar extraction more difficult and to divert valuable sucrose crystals into the by-product molasses.

There are to be a number of papers on this subject presented here. Some of these reports will be in the nature of survey results showing how widely and extensively nitrogen is being used. Other researchers will tell us of the interplay of nitrogen with soil temperature, irrigation and sugar beet plant populations. Still others will shed light upon the effect of crop residues and the carry-over of nitrogen from one crop to another. There is strong evidence that nitrogen is not dissipated—leached out—to the extent formerly believed. Some experiments on nitrogen carry-over are telling us that check plots, those without current nitrogen application, are producing as well as those with high increments. Why? Certainly not because nitrogen is not needed in sugar beet culture, but because nitrogen carry-over from other crops appears to be so great it is able to sustain a year's growth of sugar beets.

I cannot over-emphasize the importance of this phase of sugar beet agriculture, for I feel we must stem a mounting tide. We need to seek the optimum level and not exceed it to our own detriment and expense.

This highlight review, I trust, gives some indication of the many subjects to be dealt with in the course of this meeting and the significance of the investigations upon which there will be reports in the various section gatherings. Here, as we exchange the results of our labors will begin to form the shape of things to come, the future of our beet sugar industry. For it has been wisely said that three basic factors will shape our tomorrow in agriculture; our farm youth, education and research. These, after all, are the channels of continuity in all our effort and the ceaseless building of knowledge to insure that the future, as well as the present, will be fruitful, meaningful and satisfying to the souls as well as the bodies of mankind.

# Experimental Control of the Beet Leafhopper on Sugar Beets Grown for Seed[1]

HOWARD E. DORST[2]

*Received for publication July 26, 1958*

Curly top, the virus disease transmitted by the beet leafhopper (*Circulifer tenellus* (Bak.)), has greatly reduced the yield of monogerm sugar-beet seed in southern Utah and southern Nevada. In some years large numbers of leafhoppers move to fields of sugar beets grown for seed in late September or early October, at the time the plants are in the cotyledon to eight-leaf stages. Curly-top-resistant varieties of multigerm beets and the monogerm male sterile hybrids grown for seed the past three years are damaged while in the early stages of growth (3)[3].

Romney (7) in 1935 found that a pyrethrum-in-oil spray was of value in the control of the beet leafhopper on seed beets, but that the material had no residual effect. Hills et al. (5), Smith (8), and Douglass et al. (2) showed that DDT was effective against the insect for 1 or 2 weeks. Later Douglass et al. (1) showed that susceptible R & G old-type beets could be protected from infection with twelve applications of DDT. Murphy et al. (6) obtained similar results on commercial beets. Hills et al. (4) reported that systemic treatments of beet seed with Thimet would protect the seedlings for at least 2 weeks after their emergence.

At the 1956 meeting of The American Society of Sugar Beet Technologists the writer reported experiments conducted in years of different leafhopper populations and percentages of infective leafhoppers. Two applications of DDT spray on US 22/3 beets gave increases of 0.5 to 5.6 tons per acre when the population varied from 0.7 to 7.0 per square foot and the percentage of viruliferous leafhoppers ranged from 5.0 to 19.5.

Studies were conducted in 1956 and 1957 on the use of insecticides for the control of the beet leafhopper on monogerm male sterile beets grown to produce hybrid seed.

The 1956 experiment included one, two, and three applications of DDT dust and spray at 10-day intervals in four replicates. Three pounds of DDT was applied per acre. Dusts and sprays gave similar results. Two applications, the second of which was in the first week of October when the fall movement

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[1] This work was carried out in cooperation with the Utah Agricultural Experiment Station.

[2] Entomologist, Entomology Research Division, Agricultural Research Service, U.S.D.A.

[3] Numbers in parentheses refer to literature cited.

of the leafhopper was at a peak, gave an average of 85 percent reduction of leafhoppers and 95 percent reduction of obvious curly top. Applications made approximately 10 days before or after this peak did not measurably reduce the incidence of curly top. A peak population of one leafhopper per square foot was present while the beets were in the cotyledon to four-leaf stages.

In 1957 tests were made with Thimet seed treatment, and foliage applications of DDT dust and granular formulations of malathion, Thimet, Diazinon, dieldrin, and chlordane. This year the peak of the leafhopper movement to the beets occurred the last week of September. Approximately 30 percent of the leafhoppers collected in beet fields were viruliferous at this time.

Thimet-treated seed was planted in two fields, one of 6½ and the other of 3½ acres, each with an equal adjacent acreage of untreated seed. Eight ounces of Thimet in a 44-percent wettable powder with captan was used per 20 pounds of seed per acre. It reduced the leafhopper population 90 percent through the eight-leaf stage. Obvious curly top was reduced 98 percent. There was an average of 1.5 leafhoppers per square foot of row in the untreated portions of the fields.

In another field a grower made one application of 10-percent DDT dust at 20 pounds per acre with power equipment to sugar beets in the four- to six-leaf stages. It reduced the leafhopper population by 55 percent and decreased the incidence of obvious curly top by 83 percent.

A randomized-block experiment was conducted with the granular insecticides applied to plants in the cotyledon to two-leaf stages. Each plot was 12 rows wide and contained approximately ¼ acre. Four replicates were made in one field and three in another. In the untreated plots the leafhopper population at the time of application and shortly thereafter averaged 1.4 per foot of row. As shown in Table 1, best results were obtained with malathion and Thimet, but they were only slightly superior to Diazinon. Dieldrin and chlordane were less effective in the kill of leafhoppers and reduced curly top by only 33 percent.

These field experiments indicate that on monogerm beets one application of insecticide, timed to coincide with beet leafhopper movement to this crop, will reduce the incidence of obvious curly top. DDT spray or dust and granular formulations of malathion, Thimet, or Diazinon are similar in effectiveness. Thimet seed treatment is even more effective than the foliage treatments and is more practical.

**Table 1.—Control of the Beet Leafhopper and Curly Top with Granular Insecticides on Monogerm Beets Grown for Seed Showing the Rating by Duncan Multiple Range Test. 1957.**

| Granular Insecticides | | Pounds per Acre | Beet Leafhopper Population per Square Foot of Beet Row | | Curly Top Reading per 100 Foot Row in 2 Months |
|---|---|---|---|---|---|
| | | | 1 day | 6 to 9 days | |
| Field No. 1 | | | | | |
| Malathion | 8% | 85 | 0.27 | 0.5 | 1 |
| Thimet | 2% | 70 | 0.25 | 0.6 | 2 |
| Chlordane | 10% | 75 | 0.65 | 0.67 | 16 |
| Dieldrin | 5% | 100 | 0.85 | 0.78 | 8 |
| Check | | | 1.3 | 1.28 | 24 |
| Field No. 2 | | | | | |
| Thimet | 2% | 70 | 0.0 | 0.1 | 9 |
| Malathion | 8% | 85 | 0.0 | 0.2 | 5 |
| Diazinon | 2.5% | 50 | 0.1 | 0.4 | 9 |
| Dieldrin | 5% | 100 | 0.37 | 0.6 | 24 |
| Chlordane | 5% | 75 | 0.37 | 1.4 | 32 |
| Check | | | 0.66 | 1.46 | 29 |

Any two means vertical of each other in each field do not differ significantly at 95 percent level.

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# Beet Leafhopper Control in Sugar Beets by Seed or Soil Treatment

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Experiments by the senior author in 1955 indicated that treatment of sugar beet seed with phorate (Thimet) or other systemics was of value in controlling beet leafhoppers (*Circulifer tenellus* (Baker)) on plants being grown for seed in the Salt River Valley of Arizona (1)[3]. Reynolds et al. (2) tested various materials as seed and soil treatments on several crops, including sugar beets, and reported good control on beets up to the 4 to 6-leaf stage of development. In 1956 and 1957 field-plot and greenhouse tests were conducted by the authors at Phoenix, Arizona, to compare various methods of seed or soil treatment in the control of the beet leafhopper[4]. The effectiveness of some of the treatments on lepidopterous larvae was also determined.

## Small Field Plot Tests

### *Materials and Methods*

These tests were made on field plots adjoining commercial plantings of sugar beets for seed. Each plot consisted of four rows of beets 50 feet long. The plots were arranged in randomized blocks planted August 30 and 31. All treatments were replicated six times.

In 1956 all treatments were with phorate, but in 1957 both phorate and Di-Syston were used. They were applied as seed and soil treatments and as granules under the seed.

Seed treatments were based on the amount of active ingredient on 15 pounds of seed, since this is the average planting rate per acre. Both dusts and emulsions were used. The dusts were carbon impregnated with the insecticide. The seed balls were coated with this material by tumbling them in a cement mixer for about 20 minutes. For the emulsion-treated seed, a 90-percent concentrate of phorate was diluted with water to make a total of 38 ounces of emulsion per 15 pounds of seed. This emulsion was poured over the seeds as they were being tumbled in a cement mixer. They were then air-dried overnight before planting.

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[1] Entomology Research Division, Agricultural Research Service, U. S. Department of Agriculture, Phoenix, Arizona.

[2] Western Seed Production Corporation, Phoenix, Arizona.

[3] Numbers in parentheses refer to literature cited.

[4] The field plots were provided by the Western Seed Production Corporation, Phoenix, Arizona.

Spray-in-seed-row treatments were accomplished by placing a spray nozzle between the planting shoe and the cover wheel of the planter. A 3X cone-type T-jet nozzle was used with the whirl plate removed to produce a jet of liquid. Either 2 or 4 pounds of the insecticide was used in 21 gallons of water per acre. Granules were applied by drilling them into the seed row ½ to 1 inch below the seed just before planting. Commercial granules containing 2 percent of phorate or 2.5 percent of Di-Syston were used.

The effectiveness of the treatments against beet leafhoppers was determined by caging the insects on various parts of plants in different stages of development. From 5 to 10 clip cages (Figure 1) each containing 5 to 7 leafhoppers were used for each date of infestation. After the cages had remained on the plants 48 hours, they were removed and leafhopper mortalities determined. Leafhoppers for this work were collected from Russian-thistle and placed in stock cages. The clip cages were protected from the sun by shingles, and the stock cages were kept under an umbrella while they were in the field (Figure 2).

**Figure 1.—Clip cage used to confine beet leafhoppers on test plants. (Actual size ¾ inch diameter.)**

**Figure 2.—Small plots of seed beets for tests of seed and soil treatments against the beet leafhopper. Shingles protected the caged leafhoppers from the summer sun; the umbrella protected the leafhoppers in the colony cage.**

To determine the effectiveness of the treatments against lepidopterous larvae that attack seedling beets, one foot of row samples were taken in each plot and all worms counted. This was done when the plants were in the late cotyledon stage and again when they were in the 2 to 4-leaf stage.

To determine the presence of the toxicant in the beet plants at different stages of development, plant samples from plots given the higher dosage of each treatment in 1956 were sent on five dates to the American Cyanamid Company's laboratory at Stamford, Connecticut, for chemical analyses. These samples were quick-frozen, held in cold storage overnight, and shipped the next day by air freight in dry ice.

To determine the location and amount of the toxicant in the plants, samples of parts of plants grown from seed treated with phorate dust at both ½ and 1 pound per acre were obtained when they were in the six-leaf stage of development and sent to the American Cyanamid Laboratory for residue analyses. Similar samples from plots grown from seed receiving the one-pound dosage of impregnated carbon dust were also sent to the Entomology Research Division Laboratory at Yakima, Washington, for chemical analysis.

*Effect on Plants*

Plant stand counts in 1956 showed drastic reductions for the phorate emulsion seed treatments, 62 percent for the ½-pound and 97 percent for the 1-pound dosage. Some reductions were also indicated for the dust seed treatments, but these are attributed to the seeding rate rather than the effect of the phorate. The dust-treated seed did not flow through the planter as readily as did the untreated seed.

*Effects on Insects*

In 1956 leafhopper mortalities were high on the cotyledons in all stages of plant development for all treatments except the granules under seed (Table 1). Later analysis of this material showed that the phorate content of the granules was considerably below the required 2 percent. The higher dosages were usually superior to the lower dosages, especially when sprayed in the seed row. Mortalities on the first pair of true leaves were not significantly different from the check except in the 1-pound emulsion seed treatment.

**Table 1.—Percent Mortality of Beet Leafhoppers After 48 Hours on Plants in Various Stages of Development in Small Phorate-Treated Plots of Sugar Beets Grown for Seed, 1956.**

| Treatment | Pounds of Phorate per Acre | 2-Leaf (14 days)[1] | 2 to 4 Leaf (20 days) | | 4 to 6 Leaf (26 days) | | 6 to 8 Leaf (33 days) |
|---|---|---|---|---|---|---|---|
| | | Cotyledons | Cotyledons | First Pair of Leaves | Cotyledons | Second Pair of Leaves | Cotyledons |
| Seed: | | | | | | | |
| Dust | ½ | 88 | 96 | 19 | 74 | 11 | 50 |
| | 1 | 99 | 100 | 32 | 100 | 6 | 92 |
| Emulsion | ½ | 98 | 100 | 22 | 98 | 8 | — |
| | 1 | 100 | 95 | 66 | 100 | 15 | — |
| Soil: | | | | | | | |
| Spray in seed row | 2 | 71 | 72 | 16 | 64 | 7 | 34 |
| | 4 | 97 | 100 | 31 | 94 | 20 | 88 |
| Granules under seed | 3 | 20 | 50 | 16 | 30 | 7 | — |
| Untreated check | — | 8 | 58 | 13 | 19 | 12 | 16 |
| LSD at 5% level | — | 11 | 14 | 20 | 14 | [2] | 17 |

[1] Days after emergence of seedlings.
[2] Not significant by F test at 5% level.

The effectiveness of the various treatments on lepidopterous larvae is shown in Table 2. The first count was made on September 17, at which time the plants were in the cotyledon stage. At this time 92 percent of the larvae were beet armyworms (*Laphygma exigua* (Hbn.)) and 8 percent garden webworms (*Loxostege similalis* (Guen.)). At the second count, made on September 24 when the beets were in the 2-leaf stage, 87 percent were beet armyworms, 9 percent garden webworms, and 4 percent cutworms. There was a tendency toward a reduction in numbers of lepidopterous larvae in all the treatments except the granules under the seed, but the differences from the untreated checks were significant only for the emulsion seed treat-

Table 2.—Number of Lepidopterous Larvae per 10 Feet of Row in Small Phorate-Treated Plots of Sugar Beets Grown for Seed, 1956.

| Treatment | Pounds of Phorate per Acre | Cotyledons | 2 Leaf |
|---|---|---|---|
| Seed: | | | |
| Dust | ½ | 5.7 | 8.6 |
| | 1 | 5.2 | 9.4 |
| Emulsion | ½ | 5.8 | 6.9 |
| | 1 | 1.2 | 1.4 |
| Soil: | | | |
| Spray in seed row | 2 | 3.8 | 10.9 |
| | 4 | 3.0 | 7.4 |
| Granules under seed | 3 | 14.0 | 19.2 |
| Untreated check | ... | 11.2 | 10.7 |
| LSD at 5% level | | 7.8 | [1] |

[1] Not significant by F test at 5% level.

Table 3.—Percent Mortality of Beet Leafhoppers on 4-Leaf Plants from Small Plots of Sugar Beets Grown for Seed, 1957.

| Treatment | Pounds of Toxicant per Acre | Cotyledons | First Pair of Leaves |
|---|---|---|---|
| Seed with dust: | | | |
| Phorate | ½ | 98 | 34 |
| Di-Syston | ½ | 86 | 42 |
| Granules under seed: | | | |
| Phorate | 4 | 71 | 29 |
| Di-Syston | 4 | 77 | 35 |
| Untreated check | ... | 33 | 20 |
| LSD at 5% level | ... | 23 | [1] |

[1] Not significant by F test at 5% level.

ment and the spray-in-seed-row at the higher dosage when the plants were in the cotyledon stage.

In 1957 leafhopper mortalities were high for all treatments when the insects were caged on the cotyledons, but there were no significant differences due to treatment when they were on the first pair of true leaves (Table 3). Mortalities from the seed treatment with phorate dust were significantly higher than from granules placed under the seed, but this was not true of Di-Syston.

*Residue Analyses*

Results of residue analyses by the American Cyanamid Company are expressed as the sulfone analogue, while those of the Entomology Research Division are expressed as total phorate. Elton L. Clark, of the American Cyanamid Company pointed out in correspondence that in plants, phorate goes through a series of oxidation steps to yield several metabolites, all of which are more potent inhibitors of cholinestrase, and that the final oxygen sulfone analogue is about 1000 times as active as phorate.

Analyses of tops from sugar beet plants receiving the higher dosages of the various 1956 treatments (Table 4) showed the greatest amount of toxicant in 10-day-old cotyledon plants grown from dust-treated seed. By the time the plants were 17 days old and in the 2-leaf stage, those grown from dust-treated seed contained less than half as much toxicant as plants from the sprayed seed rows. Thereafter, the rate of decline was about the same until at the 10-leaf stage no phorate could be recovered from the beet tops. These plants were 12- to 14-inches tall.

**Table 4.—Parts per Million of the Sulfone Analogue of Phorate in Tops of Sugar Beets in Various Stages of Development Grown from Seed Treated in Different Ways, 1956.**

| Treatment | Pounds of Phorate per Acre | Cotyledon (10 days) | 2 Leaf (17 days) | 4 Leaf (24 days) | 6 to 8 Leaf (31 days) | 10 Leaf (52 days) |
|---|---|---|---|---|---|---|
| Seed dusted | 1 | 2.590 | 0.581 | 0.474 | 0.082 | <0.002[1] |
| Spray in seed row | 4 | 1.160 | 1.190 | .384 | .027 | < .002 |
| Granules under seed | 3 | 0.110 | .043 | <.002 | <.002 | —— |

[1] Sensitivity of the method is 0.002.

Analyses of various parts of plants in the 6-leaf stage (Table 5) showed by far the greatest amount of the toxicant in the cotyledons. There was also about twice as much of the toxicant in cotyledons of plants receiving the 1 pound as in those receiving the ½ pound dosage. Only the higher dosage showed some toxicant in the first pair of leaves. There was some phorate toxicant in the roots of the 6-leaf plants, but samples dug 7 months later from plots receiving the 1-pound dosage showed no phorate residue.

## Greenhouse Tests

Tests were made in the greenhouse to determine beet leafhopper mortalities resulting from short periods of feeding on sugar beets grown from phorate-treated seed. Since separate tests

Table 5.—Parts per Million of Phorate Toxicant in Various Parts of 6-Leaf Plants of Sugar Beets Grown from Seed Dusted at Different Rates, 1956.

| | Phorate Application per Acre | | |
|---|---|---|---|
| | ½ lb. | 1 lb. | 1 lb. |
| Plant Parts | Sulfone Analogue | | Total Phorate |
| Cotyledons | 0.257 | 0.556 | 660.0 |
| First pair of leaves | <0.002[1] | 0.085 | 100.0 |
| Second pair of leaves | <0.002 | 0.022 | 20.0 |
| Roots | 0.004 | 0.023 | 48.0 |

[1] Sensitivity of the sulfone analogue analysis is 0.002.

were run on cotyledons and first and second pairs of leaves, the data also give information on the position of the toxicant in the young plants.

Tests during November and December were run with leafhoppers collected in the field from Russian-thistle and later in the season with leafhoppers from reared colonies. Test plants were sugar beets grown in greenhouse flats from seed treated at the rate of ½ pound of phorate on 15 pounds of seed.

Insects were confined on the plants by clip cages, as in the field-plot tests, except that only one leafhopper was placed in each cage, and they were starved for 3 to 4 hours before being placed on the plants. After they had been on the treated plants for 1 hour to insure feeding, mortality readings were taken and the live insects transferred to untreated plants for 24 hours after which mortality readings were again taken. Percent mortality was also determined on untreated check plants. As shown in Table 6, feeding periods of 1 hour or less produced high mortalities. Mortality was much higher on the cotyledons than on either the first or second pair of true leaves, which is in agreement with data from the small field-plot tests.

Table 6.—Beet Leafhopper Mortalities in Greenhouse Cages on Leaves of Sugar Beets in Various Stages of Development Grown from Phorate-Treated Seed, 1956.

| Stage of Plant Development | Leaves Tested | Number of Leafhoppers | Percent Mortality over Untreated Check | |
|---|---|---|---|---|
| | | | 1 hour | 24 hours |
| Cotyledon | Cotyledons | 100 | 42 | 92 |
| 2 to 4 Leaf | Do | 50 | ... | 86 |
| | First pair | 150 | 15 | 47 |
| 4 to 6 Leaf | Do | 50 | .... | 47 |
| | Second pair | 150 | .... | 35 |

## Large Field-Plot Tests

*Materials and Methods*

These tests were on commercial plantings with seed treated with phorate-impregnated carbon dust. In 1956 all the seed was treated at the rate of ½ pound of phorate on 15 pounds of seed (or per acre). Strips of 8-11 acres each were planted with treated seed in five fields; three other fields ranging in size from 6 to 34 acres were grown entirely from treated seed.

In 1957 practically the entire acreage of seed beets in the Salt River Valley was grown from seed treated at the same rate as in 1956. In each of seven fields a strip of approximately 10 acres was planted with seed having no treatment and another strip with seed treated with 1 pound of phorate per 15 pounds of seed. All the seed was treated by a local company a few days before planting.

As far as possible beet leafhopper populations were measured weekly in all strips until the plants had reached the 10 to 12-leaf stage and were approaching 75 percent foliage cover. This was about 4 to 6 weeks after they emerged. Leafhopper populations in the fields at this time are normally on the decline. Counts were made with a square-foot counting cage (3) 25 square feet constituting a sample.

In 1957 stand counts and counts of lepidopterous larvae were made when the plants were in the late cotyledon to 2-leaf stages; 50 units of 1 foot of row each constituted a sample.

When the plants were in the 6 to 8-leaf stage or larger, curly-top counts were made to determine the effect of treatment on the disease. Counts were made in units of 5 feet of row; 20 such units, taken at random, constituted a sample.

*Effect on Plants*

Plant stands were not taken in 1956 but stands in all plots were considered satisfactory. In the 1957 plots, seed treated with 1 pound of phorate per acre produced 177 plants, seed treated with ½ pound per acre 167 plants, and untreated seed 144 plants per 10 feet of row. Some difficulty was encountered in getting the treated seed through the planters. A larger opening was therefore used and the planting rate increased, which undoubtedly accounts for the difference in stand counts. In some of the higher dosage plots a slight burning was noted on the tips of the cotyledons, but this did not affect the growth of the plants.

*Effect on Insects and Curly Top*

Beet leafhopper population during the fall of 1956 were too low to measure differences due to treatment. The average

population for all plots during September and October was 2.4 per 100 feet of row. Populations of 2.0 per 100 feet of row or less are not considered high enough to cause a measurable amount of curly top.

In 1957 phorate treatment reduced the beet leafhopper population on plants in the cotyledon and 2 to 4-leaf stages far below the check; on older plants the differences were not significant (Table 7). Beet leafhopper populations were not high even in the untreated checks, although 50 or more per 100 feet of row on small plants are of economic concern.

**Table 7.—Numbers of Beet Leafhoppers per 100 Square Feet on Plants in Various Stages of Development Grown from Phorate-Treated Seed in Large Field-Plot Tests on Commercial Plantings of Sugar Beets Grown for Seed, 1957.**

| Pounds of Phorate per Acre | Cotyledon (7 days)[1] | 2 to 4 Leaf (14 days) | 4 to 6 Leaf (21 days) | 6 to 8 Leaf (28 days) | 10 Leaf (35 days) |
|---|---|---|---|---|---|
| 1 | 1 | 9 | 30 | 11 | 12 |
| ½ | 4 | 10 | 34 | 8 | 21 |
| Untreated check | 37 | 49 | 57 | 15 | 27 |
| LSD 5% | 22 | 20 | [2] | [2] | [2] |
| 1% | 31 | 29 | [2] | [2] | [2] |

[1] Days after emergence of seedlings.
[2] Not significant by F test at 5% level.

Lepidopterous larvae occurring in the plots were primarily the beet armyworm and the yellow-striped armyworm (*Prodenia ornithogalli* Guen.). Plots grown from seed treated with 1 pound of phorate contained 16 larvae per 10 feet of row, those grown from seed treated with ½ pound 13 larvae, and untreated checks 9 larvae.

Curly top readings showed an average of 3 curly top plants per 100 feet of row for the 1-pound treatment, 5 for the ½ pound, and 10 for the untreated checks. These readings show a very low curly top incidence and under the conditions of this experiment differences due to treatment are not significant.

## Discussion

The most important fact demonstrated by these experiments is the concentration of toxicants from seed treatment with phorate or Di-Syston in the cotyledons of the sugar beet plants. This concentration of toxicants in the cotyledons does not mean that beet leafhopper control by this method is confined to seedlings. The cotyledons ordinarily remain in good condition until the plants are past the 6 to 8-leaf stage, at which time they are 10 to 12 inches tall. The beet leafhopper is a very active insect

and in moving about over the plants may feed on the cotyledons as long as they are present. Figure 3 shows the condition and prominence of cotyledons on sugar beets in the 4 to 6-leaf stage. These experiments also show that beet leafhoppers are rapidly killed by one feeding on the cotyledons of plants grown from treated seed. This is an important point in preventing the spread of curly top.

**Figure 3.—Cotyledons on sugar beet plants in the 4-6-leaf stage of development.**

## Summary

In 1956 and 1957 tests were conducted in field plots and in the greenhouse on sugar beets grown for seed to determine the comparative effectiveness against the beet leafhopper (*Circulifer tenellus* (Baker)), of various methods of seed and soil treatment with phorate and Di-Syston. The seed treatments were with impregnated carbon dusts or emulsions and the soil treatments with emulsion sprays in the seed row at planting time or granules under the seed. Dust seed treatments gave as good results as other treatments, were easier to use, and did not damage plant stands as did emulsion seed treatments. Good results were obtained with both insecticides at ½ and 1 pound on 15 pounds of seed or per acre. Cage tests with beet leafhoppers as well as analyses of plant parts showed a concentration of phorate in the cotyledons. Some control of lepidopterous larvae was indicated on young plants.

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# Effects of Sodium 2, 3-Dichloroisobutyrate, a Selective Gametocide, on Sugar Beets[1]

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## Introduction

Some form of male sterility must be used in order to obtain crosses between self-fertile inbred lines of sugar beets or to insure a high percentage of crossing between heterogeneous strains. Cytoplasmic and Mendelian forms of male sterility have been reported (2, 3)[3], but much time and effort are required to incorporate them into desired lines or strains. Since sodium 2,3-dichloroisobutyrate (FW-450) has been shown to have a selective gametocidal effect on cotton (1), its effectiveness as a selective gametocide on sugar beets was tested. This paper reports results of preliminary studies dealing with this chemical. The objectives of this study were to determine whether sodium 2,3-dichloroisobutyrate has a selective gametocidal effect on sugar beets, to determine the optimum concentration and time of application of the chemical if a selective gametocidal action exists, and to obtain information on the nature and extent of undesirable side effects.

## Materials and Methods

A greenhouse experiment and a field experiment were conducted in 1958 to determine the effects of FW-450 on sugar beets. A carrier rate of 100 gallons per acre was used in both experiments. The spray material was applied with a compressed-air sprayer consisting of an air storage tank into which air was introduced from a compressor, a regulator valve to control the pressure at which the material was applied, a reservoir for the liquid, and a spray nozzle. By calibrating the sprayer before making the applications, the dosage administered was controlled very accurately. Individual plants, with a shield around each to prevent drift of the spray material, were sprayed.

### *Field Experiment*

The experimental design for the field experiment was a modified split-split plot with four replications. The whole plots were varieties, the sub plots times of application, and the sub-sub

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[2] Geneticist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture.

[3] Numbers in parentheses refer to literature cited.

plots concentrations of FW-450. The plant material consisted of 192 roots from each of three commercial varieties (A54-1, A54-6, and A54-7), a total of 576 roots. The roots were grown in 1957, overwintered in a root cellar, and planted on April 30, 1958. Each replication consisted of three blocks, each block representing a variety. Each variety block was divided into three groups of four rows. One group was given an initial application at emergence (May 19). A second group was given an initial application at early bolting (May 29), while the third group in each block was given an initial application at the pollen-mother-cell stage (June 6). One row within each group was untreated and served as a check and a pollen source, one received a treatment of ⅓ percent, one 1.0 percent, and one 3.0 percent FW-450 by weight. Each row consisted of four plants spaced 2 feet apart with 3 feet between rows.

Modifications of the split-split plot design were made to obtain information on the effect of repeated applications. Each plot treated at emergence was split in half, and one half, chosen at random, received repeat treatments at the early bolting and pollen-mother-cell stages while the other half received only the emergence spraying. The plots treated at early bolting also were divided and one-half received an additional treatment at the pollen-mother-cell stage.

Data were obtained for the following characters: period to first flowering, period from first flowering to first pollen shedding, seed yield, percentage of plants which shed pollen, and germination percentage. Period to first flowering was measured as the days from May 31 to the date when the first flower was observed to be open. Date of first pollen shedding was recorded as the first day on which any flower on the plant was observed to shed pollen. Period from first flowering to pollen shedding was the days from the date of first flowering to the date of first pollen shedding. The data listed were taken on an individual plant basis. Germination percentages were obtained for the following treatments: check, ⅓ and 1.0 percent applied at the pollen-mother-cell stage, ⅓ and 1.0 percent applied at early bolting, and ⅓ percent applied at both early bolting and the pollen-mother cell stage. Composite samples of two grams of seed from each of 24 plants from each treatment were obtained. Eight 100-seedball lots were taken from each such sample. The 48 lots thus obtained were arranged in a randomized complete-block design in the germinator. Germination percentage was computed as the percent of seedballs showing at least one radicle.

Since the three varieties were segregating for red and green hypocotyl color, each root in the field was classified for bud

color, and hypocotyl color counts were made on the open-pollinated progeny of the green-hypocotyl plants in the check plots, in the check plots in the pollen-mother-cell groups, in the plots to which the ⅓ percent treatment was applied at the pollen-mother-cell stage, and in the plots to which the 1.0 percent treatment was applied at the pollen-mother-cell stage. If an appreciable amount of selfing were occurring in the green-hypocotyl parents, then a comparison of the percentage of red-hypocotyl plants obtained in the progeny of green-hypocotyl plants in the check plots with the percentage of red-hypocotyl plants in the progeny of green-hypocotyl plants in the treated plots should give an indication of the effectiveness of the gametocide in promoting cross-fertilization.

*Greenhouse Experiment*

The greenhouse planting consisted of 40 quarter roots of each of two inbred lines; 52-407, which has red roots, and 54-565, which has yellow roots. The quarters of these lines were alternated. Spray applications consisted of a ½ percent solution of FW-450. Alternate pairs of plants, one of each inbred, were sprayed; thus one-half of the plants of each line were treated while the other half were untreated and served as pollen parents and as a check on the effectiveness of the spray applications. Of the pairs of sprayed plants, one-half received two applications—one at the emergence stage (April 28) and one at the early bolting stage (May 12). The other pairs of sprayed plants received an additional spraying at the pollen-mother-cell stage (May 26).

Hypocotyl color counts on progeny of 54-565 were made on composite samples of seed from the untreated check plants, the plants sprayed twice, and the plants sprayed three times. Since 54-565 is self-fertile, the percentage of red hypocotyl plants in progeny of check plants as compared with the percentage obtained in progeny of the treated plants provides a measure of the effectiveness of the gametocide. Seed yield was measured as grams per plant. Composite samples of seed from each of the three treatments from each inbred were used to obtain germination percentage by the method described for the field experiment.

*Statistical Methods*

The days to first flowering and seed yield data from the field experiment were subjected to analysis of variance. Since a single orthogonal analysis of the design used was not possible, separate analyses of variance were made for time of single application

and for number of applications. Chi-square analysis was used for the data on percent of plants shedding pollen, germination percentage, and hypocotyl color.

## Results

The results of the field and greenhouse experiments will be discussed separately.

*Field Experiment*

Homogeneity chi-square tests reveal that, for the single applications, the emergence and early-bolting applications are different in percent of plants shedding pollen with odds between 19:1 and 49:1 (see Table 1). Further analysis of Table 1 reveals that the average percent of plants shedding pollen is less for the single applications at the pollen-mother-cell stage than for single applications at either the emergence or early-bolting stage with odds greater than 99:1. Within the pollen-mother-cell stage, the 1.0- and 3.0-percent applications have significantly lower percentages of plants shedding pollen than the ⅓-percent application or the check. The double and triple applications reduced the percent of plants shedding pollen significantly more than any of the single applications. The repeated applications of the 1.0 and 3.0 percent solutions caused the greatest reduction in percent of plants shedding pollen.

The means for the characters number of days from May 31 to first flowering, number of days from first flowering to pollen shedding, and seed yield in grams for the various concentration and time of application combinations are shown in Table 2. The 1.0-percent treatment applied three times and the 3-0-percent applied twice delayed flowering about 5 days, the 3.0 percent applied three times delayed flowering about 8 days. Both delays were significant.

The means for days from first flowering to pollen shedding were computed from only those plants which actually shed pollen. Pollen shedding on the check plots occurred, on the average, one to two days after the first flowers were observed to be open. Of the single applications, those made at the early bolting and the pollen-mother-cell stages with concentrations of 1.0 and 3.0 percent delayed pollen shedding 10 to 12 days, while a single application of ⅓ percent at the pollen-mother-cell stage or of 3.0 percent at emergence delayed pollen shedding about 6.5 days. All the repeat applications delayed pollen shedding an average of at least 5 days.

The analyses of variance for seed yield revealed highly significant differences between concentrations, number of appli-

Table 1.—Total Number of Plants in Three Varieties of Sugar Beets, and Percent of Plants Shedding Pollen for Time of Application and Concentration Combinations in Field Gametocide Test.

| Stage of Growth at Application and Concentration | Total Plants (Number) | Plants Shedding (Percent) |
|---|---|---|
| **Emergence** | | |
| Check | 46 | 100.0 |
| 1/3% | 24 | 95.8 |
| 1.0% | 22 | 81.8 |
| 3.0% | 24 | 79.2 |
| Total[1] | 70 | 85.7 |
| **Early Bolting** | | |
| Check | 46 | 97.8 |
| 1/3% | 23 | 82.6 |
| 1.0% | 24 | 66.7 |
| 3.0% | 23 | 65.2 |
| Total[1] | 70 | 71.4 |
| **Pollen Mother Cell** | | |
| Check | 46 | 97.8 |
| 1/3% | 47 | 87.2 |
| 1.0% | 47 | 38.3 |
| 3.0% | 46 | 26.1 |
| Total[1] | 140 | 50.7 |
| **Early Bolting and Pollen Mother Cell** | | |
| Check[2] | 46 | 97.8 |
| 1/3% | 24 | 70.8 |
| 1.0% | 24 | 29.2 |
| 3.0% | 24 | 0.0 |
| Total[1] | 72 | 33.3 |
| **Emergence, Early Bolting, and Pollen Mother Cell** | | |
| Check[3] | 46 | 100.0 |
| 1/3% | 24 | 79.2 |
| 1.0% | 23 | 34.8 |
| 3.0% | 23 | 4.3 |
| Total[1] | 70 | 40.0 |

[1] Excluding the check.
[2] Check is the same as that for the Early Bolting block.
[3] Check is the same as that for the Emergence block.

cations, and times of application. From Table 2 it can be seen that all treatments except the 1/3 percent applied at emergence reduced seed yield to some extent. Of the other treatments, the 1.0 percent application at emergence reduced seed yield the least. The single 1/3 percent applications at early bolting and the pollen-mother-cell stage, and the double application of 1/3 percent caused about the same reduction in seed yield, to an average of 103.3 grams per plant compared with 131.7 grams per plant for the average of the checks. The rest of the treat-

ments range from an average of 90.1 grams for 1.0 percent applied at early bolting to 5.9 grams for 3.0 percent applied three times.

The number of red- and green-hypocotyl plants of each variety in the field experiment is shown in Table 3. The red-

**Table 2.—Period to First Flowering, Period from First Flowering to Pollen Shedding and Seed Yields for Treatments Applied to Three Varieties of Sugar Beets in the Field Gametocide Test.**

| Stage of Growth at Application and Concentration (percent) | Days from May 31 to First Flowering (Number) | Days from First Flowering to Pollen Shedding (Number) | Seed Yield (Grams) |
|---|---|---|---|
| **Emergence** | | | |
| Check | 19.2 | 1.9 | 131.2 |
| 1/3% | 18.9 | 3.4 | 128.9 |
| 1.0% | 18.6 | 4.9 | 118.0 |
| 3.0% | 21.0 | 8.2 | 77.1 |
| **Early Bolting** | | | |
| Check | 19.4 | 1.0 | 137.2 |
| 1/3% | 20.5 | 5.7 | 100.4 |
| 1.0% | 19.5 | 10.8 | 90.1 |
| 3.0% | 20.3 | 10.9 | 63.1 |
| **Pollen Mother Cell** | | | |
| Check | 20.6 | 1.1 | 126.6 |
| 1/3% | 19.7 | 7.7 | 104.6 |
| 1.0% | 19.9 | 12.7 | 72.7 |
| 3.0% | 20.5 | 11.9 | 35.9 |
| **Early Bolting and Pollen Mother Cell** | | | |
| Check | 19.4 | 1.0 | 137.2 |
| 1/3% | 20.9 | 9.8 | 105.0 |
| 1.0% | 20.9 | 12.3 | 38.9 |
| 3.0% | 24.6 | ..... | 10.0 |
| **Emergence, Early Bolting, and Pollen Mother Cell** | | | |
| Check | 19.2 | 1.9 | 131.2 |
| 1/3% | 21.0 | 10.2 | 69.1 |
| 1.0% | 24.6 | 13.4 | 27.5 |
| 3.0% | 27.8 | 7.0 | 5.9 |

**Table 3.—Number of Sugar Beet Plants with Red- and Green-Hypocotyls, $q^2$, and q Values for Field Experiment.**

| Variety | Hypocotyl color | | $q^2$ | q |
|---|---|---|---|---|
| | Red | Green | | |
| A54-1 | 162 | 28 | 0.1474 | 0.3839 |
| A54-6 | 130 | 50 | 0.2778 | 0.5271 |
| A54-7 | 149 | 39 | 0.2074 | 0.4554 |

and green-hypocotyl plants were distributed at random throughout the field. Assuming that each variety represents a panmictic population, q, the frequency of the r gene, can be estimated as the square root of $q^2$, the proportion of green-hypocotyl plants in each variety. Weighting the values of q thus obtained by the number of plants in each population values of $q = 0.4543$ and $p = 0.5457$, where $p = 1\text{-}q$, are obtained.

The number of red- and green-hypocotyl plants obtained by germinating open-pollinated seed from green-hypocotyl plants in plots of certain treatments are shown in Table 4. The percent of red-hypocotyl plants in these is a direct estimate of p since all the red-hypocotyl plants had to result from cross-fertilization. Chi-square values for the fit of the obtained numbers of red-hypocotyl plants to the number expected on the basis of random mating are shown in Table 5. From this table it can be seen that while none of the individual chi-squares exceeded the 5

**Table 4.—Number of Red- and Green-Hypocotyl Plants in the Progeny of Green-Hypocotyl Sugar Beet Plants for Certain Treatments in the Field Experiment.**

| Treatment | Hypocotyl Color | | | Percent Red | |
|---|---|---|---|---|---|
| | Red | Green | Total | Obtained | Expected[2] |
| Check | 357 | 333 | 690 | 51.74 | 54.57 |
| PMC[1] Check | 217 | 192 | 409 | 53.06 | 54.57 |
| PMC 1/3% | 64 | 59 | 123 | 52.03 | 54.57 |
| PMC 1.0% | 57 | 65 | 122 | 46.72 | 54.57 |

[1] PMC designates pollen-mother-cell.
[2] On the basis of random mating.

**Table 5.—Chi-Square and P Values for Fit of Obtained Numbers of Red-and Green-Hypocotyl Sugar Beet Seedlings to the Numbers Expected on the Basis of Random Mating.**

| Treatment | D.F.[1] | Chi-Square | P |
|---|---|---|---|
| Check | 1 | 2.2229 | 0.20-0.10 |
| PMC[2] Check | 1 | 0.3791 | 0.70-0.50 |
| PMC 1/3% | 1 | 0.3151 | 0.70-0.50 |
| PMC 1.0% | 1 | 3.0473 | 0.10-0.05 |
| Sum | 4 | 5.9644 | 0.30-0.20 |
| Total | 1 | 4.1255 | 0.05-0.02 |
| Interaction | 3 | 1.5389 | 0.70-0.50 |

[1] D.F. designates degrees of freedom.
[2] PMC designates pollen-mother-cell.

percent probability level, the chi-square for the totals fell between the 5 and 2 percent points. The sum of the individual chi-squares with four degrees of freedom fell between the 0.30 and 0.20 probability levels while the interaction chi-square with three degrees of freedom fell between the 0.70 and 0.50 levels. Study of Table 4 reveals that fewer red-hypocotyl plants were obtained than were expected in all of the populations. The difference is so small that for all practical purposes the populations can be considered as random mating.

The treatments fall into three distinct groups as regards percentage of germination (see Table 6). Germination percentage was reduced the least by the 1/3 percent treatment at early bolting. Reduction in germination percentage was intermediate for the 1/3 percent treatment at the pollen-mother-cell stage and greatest for 1.0 percent at the pollen-mother-cell stage, 1.0 percent at early boting, and 1/3 percent applied at both early bolting and pollen-mother-cell stages.

**Table 6.—Total Number of Seedballs of Three Varieties of Sugar Beets, and the Percentage of Germination for Certain Treatments from the Field Gametocide Test.**

| Treatment | Seedballs Tested (Number) | Seedballs Germinating (Percent) |
|---|---|---|
| Check | 800 | 49.1 |
| 1/3% PMC[1] | 800 | 35.9 |
| 1.0% PMC | 800 | 23.1 |
| 1/3% EB[2] | 800 | 43.6 |
| 1/3% EB & PMC | 800 | 26.0 |
| 1.0% EB | 800 | 29.0 |

[1] PMC designates pollen-mother-cell.
[2] EB designates early bolting.

*Greenhouse Experiment*

Since 54-565 is rr and 52-407 is RR any red-hypocotyl plants in the progeny of 54-565 must have resulted from crosses with 52-407. From Table 7 it can be seen that the percentage of red-hypocotyl plants in a composite sample of seed from the untreated check plants of 54-565 is only 3.51. This indicates that inbred 54-565 is mostly self-fertile. The progeny of plants of 54-565 which were sprayed twice contained 13.89 percent red-hypocotyl plants while progeny of those which were sprayed three times contained 40.27 percent red-hypocotyl plants. Chi-square tests reveal that the proportion of red-hypocotyl plants, and thus the percentage of crossing, is significantly higher for the plants sprayed three times than for either the check plants or those sprayed twice.

Table 7.—Number of Red- and Yellow-Hypocotyl Seedlings in Progeny of Sugar Beet Inbred 54-565.

| Number of Sprayings | Total Plants (Number) | Plants with Red-Hypocotyl (Percent) |
|---|---|---|
| Check (0) | 1940 | 3.51 |
| Two | 1497 | 13.89 |
| Three | 956 | 40.27 |

Study of Table 8 reveals that the seed yield of 54-565 was not reduced by two applications of gametocide and that three applications reduced seed yield only 10 grams per plant. For 52-407 two sprayings reduced seed yield 18.61 grams while the third spraying reduced seed yield an additional 15.49 grams.

Table 8.—Mean Seed Yield in Grams per Plant for Two Inbred Lines of Sugar Beets Sprayed with FW-450 0, 2 and 3 Times in the Greenhouse Test.

| Number of Sprayings | Inbred | | Mean |
|---|---|---|---|
| | 54-565 | 52-407 | |
| Check (0) | 132.11 | 126.21 | 129.16 |
| Two | 133.80 | 107.60 | 120.70 |
| Three | 122.11 | 92.11 | 107.11 |
| Mean | 130.18 | 113.24 | 121.71 |

The numbers and percentages of seedballs germinated from the greenhouse seed are shown in Table 9. Chi-square analysis of these data reveals that, on the average, two treatments significantly increased the germination percentage while three sprayings caused a significant decrease in germination percentage.

Table 9.—Germination Percentage for Two Inbred Lines of Sugar Beets Sprayed with FW-450 0, 2 and 3 Times in the Greenhouse Test.

| Inbred and Number of Sprays | Total Seedballs (Number) | Germinated Seedballs (Percent) |
|---|---|---|
| 54-565 | | |
| Check | 800 | 87.1 |
| Two | 800 | 91.2 |
| Three | 800 | 76.1 |
| 52-407 | | |
| Check | 800 | 86.8 |
| Two | 800 | 89.1 |
| Three | 800 | 58.2 |

The decrease obtained from 52-407 sprayed three times is larger than the decrease obtained from 54-565 sprayed three times with odds greater than 99:1.

## Discussion

Eaton (1) reported induction of male sterility in cotton by use of FW-450. The results reported in this paper provide preliminary data on the effects of this chemical on sugar beets.

The results of the field experiment indicate that complete elimination of pollen shedding by application of the chemical at the stages studied is possible only with extremely heavy applications. Pollen shedding could be delayed as much as a week or 10 days by use of much smaller applications. The greatest degree of control with the least reduction in viable seed produced was achieved with the ⅓-percent application at the pollen-mother-cell stage. Plants given this treatment had a germination percentage of 35.9 percent, compared to 49.1 percent for the check; seed yield of 104.6 grams per plant, compared to 126.6 for the check; 87.2 percent of the plants shedding pollen; and period to pollen shedding, for plants which did shed pollen, of 7.7 days.

Significant delays in date of first flowering were found only where extremely heavy applications were made. In these cases the delay was probably caused by severe burning of the main flowering stalk so that first flowering had to await the development of secondary flowering branches. No significant delay in flowering was found when potentially useful concentrations of the chemical were used.

Hypocotyl color counts made on the progeny of green-hypocotyl plants indicated that the varieties used in the field experiment are for all practical purposes completely cross-pollinated. Thus it should be possible to obtain synthetic varieties, made up of individuals selected from such populations, which are essentially completely cross-pollinated.

When a self-fertile inbred line was treated with three applications of a ½-percent solution in the greenhouse the percent of hybrids was increased from 3.51 to 40.27 with only a slight reduction in seed yield and germination percentage. The figure 40.27 percent represents only the measureable crossing which occurred. Since 50 percent of the untreated plants were yellow-rooted, the amount of actual cross-pollination caused by the gametocide is probably somewhat greater than 40.27 percent. Thus chemical control of pollen formation offers an effective method of forcing certain self-fertile inbred lines to hybridize.

For the plant breeder interested in testing combining ability of self-fertile lines or in obtaining crosses between populations which, while not self-fertile, are intra-population fertile, chemically induced male sterility may be an extremely useful tool.

Another aspect of the problem apparent from the greenhouse experiment is the different responses of the two inbred lines to the chemical. Inbred 52-407 showed a greater reduction in both seed yield and germination percentage than 54-565 when three applications of the chemical were made. This indicates that some lines are more resistant to the effects of FW-450. Similar results have been reported for cotton (1).

Many problems connected with the use of selective gametocides on sugar beets remain to be solved. From the practical viewpoint, more work needs to be done in determining the exact combination of concentrations, carrier rates, time of application, and number of applications which will give maximum selective gametocidal action with minimum undesirable effects. A large number of strains, inbred lines, hybrids, and commercial varieties should be treated to determine the range of response to the chemical. From a theoretical standpoint, it would be of interest to study the cytological and histological effects of the chemical. At what stage in the process of anther and pollen formation does it have its effects? Another problem which should be studied is that of possible production of mutations in the megasporocytes of treated plants.

Although many problems remain unsolved, it can be concluded from the results of these preliminary investigations that some lines of sugar beets can be made effectively male sterile while retaining the major part of their seed-producing ability; the optimum concentration of FW-450, when applied at a carrier rate of 100 gallons per acre, is probably between 1/3 and 1/2 percent; and inbred lines differ in their response to the chemical.

## Summary

(a) A field and a greenhouse experiment were conducted to determine the effectiveness of sodium 2,3-dichloroisobutyrate (FW-450) as a selective gametocide on sugar beets.

(b) Concentrations used in the field experiment were 1/3%, 1.0%, and 3.0% applied at a carrier rate of 100 gallons per acre. Stages of growth at time of application were emergence; early bolting; pollen-mother-cell stage; early bolting, and the pollen-mother-cell stage; and emergence, early bolting, and the pollen-mother-cell stage. All possible combinations of times of application and concentrations were applied to three varieties in four replications of a modified split-split plot design.

(c) A concentration of ½ percent at a carrier rate of 100 gallons per acre was used in the greenhouse experiment. Two different treatments (applications at emergence and early bolting and applications at emergence, early bolting, and the pollen-mother-cell stage) were used. Forty quarter roots of each of two inbred lines were used.

(d) Of the treatments used in the field experiment, applications of ⅓ percent at the pollen-mother-cell stage gave a maximum of delay in pollen shedding with a minimum of adverse effect.

(e) Hypocotyl color counts on seedlings obtained from green-hypocotyl plants in the field experiment revealed that the three varieties used are essentially completely cross-pollinated.

(f) Hypocotyl color counts on progeny of the yellow-rooted inbred used in the greenhouse study revealed that the percent of hybrids had been increased from 3.51 for the check to 40.27 for plants treated three times.

(g) Different responses to the effects of the gametocide, as measured by seed yield and germination percentage, were found for the two inbreds studied.

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# Interaction of Components of Impurity and Location in Hybrids from Inbred Lines of Sugar Beets

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The inbred CT9 (6)[2], a curly-top resistant self-fertile line of sugar beets developed by the U. S. Department of Agriculture, is now recognized as a valuable component in the parentage of commercial hybrid sugar beets. CT9 hybrids are usually higher in sugar percentage than one would expect from analyses of the CT9 inbred beets grown under similar conditions. Hybrids with CT9 are sometimes exceptionally high in purity (7, 8). Chemical analyses of roots of six different hybrids grown at Twin Falls, Idaho, and at Salt Lake City, Utah, help to explain why CT9 hybrids may be exceptionally high in purity at one location but not at another.

## Materials and Methods

Hybrid combinations were made between two types of male-steriles as female parents and six curly-top resistant inbreds as pollinators. One male-sterile, 211H3, was the cytoplasmic type (4), considered the equivalent of commercial variety US 22/3, and will be designated US 22 MS. The second source of male-sterility was a Mendelian type (5) designated US 35 *aa*, where *a* represents the recessive gene for abortion of pollen. US 22 is a yield-type curly-top resistant variety, whereas US 35 is a sugar-type curly-top resistant variety.

Five of the six pollinators (CT9, CT7, 289, 5030 and 5060) were self-fertile inbreds. Each line had been selfed two to five generations. Line CT9 was from a new source, sometimes indicated with the designation "New CT9," which carries a higher degree of curly-top resistance than the original. The sixth pollinator, SL 50, was a composite population consisting of a group of curly-top resistant, self-fertile lines selected for high sugar percentage.

The hybrids were grown in field plots at two locations, Salt Lake City, Utah, on Taylorsville loam type, heavy phase (3), and Twin Falls, Idaho, on soil type classified as Portneuf silt

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[2] Numbers in parentheses refer to literature cited.

loam, deep phase, good drainage (1). At both locations the fields selected were well known for their high productive capacity, which had been built up over a period of years by good cultural practices and regular fertilizer applications. At Salt Lake City the salt content of the soil was known to be relatively high (3) and the Utah Lake irrigation water used from the Jordan River was also known to be relatively high in salt content (10).

At harvest the beets in each plot were weighed and two ten-beet samples taken for sugar and other chemical analyses. All chemical analyses were made at Salt Lake City, necessitating the freezing of the pulp samples from Twin Falls. In addition to the usual sugar and apparent purity determinations, analyses were made for sodium, potassium, and amino nitrogen (8, 9). Amino N in the root, as glutamine, was determined on clarified filtrate (26 grams of pulp digested in 177 ml $H_2O$ and 0.7 grams Horne's dry lead) by the Stanek-Pavlas method, using the spectrophotometer as the absorption instrument. Sodium and potassium in the root were determined on part of the same filtrate by the use of the flame spectrophotometer. Apparent purity, referred to simply as purity, is the ratio of sugar determined by the saccharimeter to total solids determined by the dipping or flow-through refractometer.

The field tests were conducted as split-plot designs with four blocks (replications) at each of the two locations. Whole-plot treatments were hybrids of the female parents (US 22 MS and US 35 *aa*) which were alternated systematically in the block instead of being randomized. Hybrids of the six different pollinators were randomized within each whole plot. The object was to make critical measurements of the influence of pollinators.

Single plots at Salt Lake City consisted of two rows 24 feet long, and roots of the entire plot were weighed for yield data. At Twin Falls, Idaho, single plots consisted of four rows 50 feet long and the two center rows of each plot were weighed for yield data.

## Experimental Results

The variance analyses (Table 1) show highly significant differences between locations for all variables. Highly significant differences for pollinators are also shown for most all measurements. Females differed significantly only in Na content. Two mean square values, 3.12 under pollinators and purity and 631 under pollinators and Na content, would be considered significant if compared directly with error c (Table 1). However,

Table 1.—Variance Analyses.

Table 1.—Variance Analyses.

| Source of Variation | Degrees of Freedom | Mean Squares for: Acre Yield: Gross Sugar Lbs. 10,000 | Acre Yield: Tons Beets | Chemical Analyses: Sugar Percent | Chemical Analyses: Purity Percent | Chemical Analyses: Na, ppm 100 | Chemical Analyses: K, ppm 100 | Chemical Analyses: Amino N, ppm 10.000 | Significant F Values: 5% Point | Significant F Values: 1% Point |
|---|---|---|---|---|---|---|---|---|---|---|
| Locations | 1 | 8568[2] | 1,262.22[2] | 126.04[2] | 147.76[2] | 32,893[2] | 153,200[2] | 2678 | 5.99 | 13.74 |
| Blocks within locations (Error a) | 6 | 195 | 69.33 | 1.35 | 7.09 | 706 | 3,899 | 325 | | |
| Females | 1 | 8 | 0.00 | 1.66 | 0.65 | 1,298[2] | 163 | 120 | 5.99 | 13.74 |
| Females × locations | 1 | 28 | 4.05 | 0.70 | 1.28 | 396 | 41 | 1 | 5.99 | 13.74 |
| Error b | 6 | 56 | 24.09 | 0.86 | 3.09 | 84 | 504 | 243 | | |
| Pollinators | 5 | 109[2] | 76.47[2] | 3.72[2] | 3.12 | 631 | 3,049[2] | 227[2] | 2.37 | 3.34 |
| Pollinators × locations | 5 | 28 | 9.80 | 0.44 | 4.45[2] | 160[1] | 434 | 15 | 2.37 | 3.34 |
| Pollinators × females | 5 | 24 | 3.96 | 0.21 | 0.81 | 30 | 440 | 33 | 2.37 | 3.34 |
| Pollinators × females × locations | 5 | 13 | 7.99 | 0.22 | 2.21 | 17 | 107 | 32 | 2.37 | 3.34 |
| Error c | 60 | 15 | 5.46 | 0.27 | 1.03 | 49 | 284 | 28 | | |
| Total | 95 | | | | | | | | | |

[1] = Significant at 5% point
[2] = Significant at 1% point

these two mean squares include variability for the conspicuous pollinator × location interactions. The pollinator × location interactions were significant for both purity and Na content.

Averages for locations, females and pollinators, are shown in Table 2. Averages for pollinators at each location are shown in Table 3. All hybrids took up more Na at Salt Lake City than at Twin Falls, Idaho, but the CT9 hybrids took up more than any of the other hybrids. There was a tendency for the same with K but the interaction for pollinators × locations (Table 1) was not significant. The SL 50 hybrids behaved somewhat like the CT9 hybrids. The CT7 and 289 hybrids with their low Na and K but very high amino N content were decidedly different. The chemical analyses for all hybrids are in line with analyses of the respective inbreds which were used as pollinators in production of the hybrids (8). Hybrids of 5060 showed the highest purity, 88.3 at Salt Lake City, but this does not represent a statistically significant superiority compared with the other hybrids. Comparing the two types of female parentage (Table 2) one observes that the tonnages of the respective hybrids were exactly the same, but higher sugar and lower Na were observed from the US 35 *aa* hybrids.

**Table 2.—Average Yields and Analyses of Hybrids Summarized for Pollinators, Female Parents, and Locations.**

| Parentage and Location | Acre Yield: Gross Sugar Pounds | Acre Yield: Tons Beets | Sugar Percent | Purity Percent | Na ppm | K ppm | Amino N ppm | Beets per 100 Feet of Row |
|---|---|---|---|---|---|---|---|---|
| | | | Female parents combined, means of 16 plots | | | | | |
| **Pollinator** | | | | | | | | |
| CT9 | 10,586 | 32.1 | 16.45 | 89.3 | 442 | 2545 | 3275 | 93 |
| CT7 | 9,976 | 28.8 | 17.27 | 88.4 | 265 | 2348 | 4100 | 95 |
| 5030 | 9,366 | 27.4 | 16.87 | 88.1 | 335 | 2460 | 3825 | 94 |
| 5060 | 9,916 | 28.3 | 17.40 | 88.8 | 335 | 2538 | 3700 | 94 |
| 289 | 9,088 | 25.4 | 17.80 | 88.5 | 310 | 2190 | 4325 | 90 |
| SL 50 | 9,822 | 28.8 | 16.88 | 88.2 | 392 | 2512 | 3650 | 84 |
| LSD 5% | 387 | 2.33 | 1.65 | 1.02 | 70 | 169 | 532 | |
| | | | Pollinators combined, means of 48 plots | | | | | |
| **Female parent** | | | | | | | | |
| US 22 MS | 9,734 | 28.5 | 16.98 | 88.5 | 383 | 2446 | 3708 | 93 |
| US 35 *aa* | 9,850 | 28.5 | 17.24 | 88.6 | 310 | 2418 | 3917 | 91 |
| | | | Genotypes combined, means of 48 plots at each location | | | | | |
| **Location** | | | | | | | | |
| Twin Falls, Idaho | 11,682 | 32.1 | 18.26 | 89.8 | 162 | 2033 | 4333 | 93 |
| Salt Lake City, Utah | 7,904 | 24.8 | 15.97 | 87.3 | 532 | 2830 | 3292 | 90 |

Normally one expects the highest purity to be associated with the highest sugar percentage but this was not true in the test at Twin Falls, Idaho. The CT9 hybrids with 91.2% purity were significantly higher in purity than any of the other hybrids while the average sugar percentage, 17.85%, was lowest of all hybrids.

## Discussion

The three chemical determinations, amino N, Na, and K, representing some of the components of impurity or soluble non-sugar constituents in sugar beets, were chosen for the investigations because of their ease and accuracy of determination, and because they are representative of the major impurities with which the sugar processor is obliged to deal. The amino N measurement is considered an index to the total quantity of objectionable or soluble N because it has been shown to be highly correlated with total N and total soluble N (2, 7, 9). Inorganic salts constitute the other major component of impurity. Determinations additional to Na and K would probably be helpful, but Na and K at least give some index to the total quantity of inorganic salts present.

Under an environment such as that at Twin Falls, Idaho, where amino N appears to have been the major contributor to impurity, one would expect varieties low in amino N, like the CT9 hybrids, to be low in total impurities. To explain the fact that similar results were not obtained at Salt Lake City with CT9 hybrids requires consideration of other impurities consisting of inorganic salts represented by the Na and K measurements. The CT9 hybrids on the more saline soil at Salt Lake City were high (Table 3) in sodium and potassium. The authors assume, therefore, that when the salt content of the soil is high the CT9 hybrids may be expected to have less advantage in purity. If an inbred could be developed that would produce hybrids low in root sodium and potassium, similar to CT7 hybrids, and also low in amino N like the CT9 hybrids, then such varieties might have the advantage of higher purity at both locations. Promising studies of such a hybrid are now in progress.

## Summary

Twelve hybrids, obtained by the use of six pollinators in combination with two types of male sterility, were grown in replicated plots at two locations: Twin Falls, Idaho, and Salt Lake City, Utah. Root yields were recorded and root analyses were made for sugar, purity, Na, K, and amino N. The most productive hybrids were obtained with the inbred CT9 as the

Table 3.—Means by Locations and Pollinators, and Differences Between Locations.

| Pollinator | Twin Falls, Idaho | Salt Lake City, Utah | Difference | Pollinator | Twin Falls, Idaho | Salt Lake City, Utah | Difference |
|---|---|---|---|---|---|---|---|
| | Percent purity | | | | Amino N, ppm | | |
| CT9 | 91.2 | 87.5 | 3.7 | CT9 | 3800 | 2750 | 1050 |
| CT7 | 89.3 | 87.5 | 1.8 | CT7 | 4800 | 3400 | 1400 |
| 5060 | 89.3 | 88.3 | 1.0 | 5060 | 4150 | 3250 | 900 |
| 5030 | 89.3 | 86.9 | 2.4 | 5030 | 4350 | 3300 | 1050 |
| 289 | 89.9 | 87.2 | 2.7 | 289 | 4850 | 3800 | 1050 |
| SL 50 | 90.0 | 86.5 | 3.5 | SL 50 | 4050 | 3250 | 800 |
| LSD 5% | 1.16 | NS | | LSD 5% | 629 | 877 | |
| | Na, ppm | | | | K, ppm | | |
| CT9 | 225 | 660 | 435 | CT9 | 2110 | 2980 | 870 |
| CT7 | 130 | 400 | 270 | CT7 | 1940 | 2755 | 815 |
| 5060 | 160 | 510 | 350 | 5060 | 2200 | 2875 | 675 |
| 5030 | 155 | 515 | 360 | 5030 | 2095 | 2825 | 730 |
| 289 | 130 | 490 | 360 | 289 | 1820 | 2560 | 740 |
| SL 50 | 170 | 615 | 445 | SL 50 | 2035 | 2990 | 955 |
| LSD 5% | 50 | 134 | | LSD 5% | 185 | 289 | |
| | Percent sugar | | | | Tons per acre | | |
| CT9 | 17.85 | 15.05 | 2.80 | CT9 | 35.0 | 29.2 | 5.9 |
| CT7 | 18.25 | 16.30 | 1.95 | CT7 | 32.0 | 25.6 | 6.4 |
| 5060 | 18.35 | 16.45 | 1.90 | 5060 | 31.8 | 24.9 | 6.9 |
| 5030 | 18.10 | 15.65 | 2.45 | 5030 | 32.0 | 22.8 | 9.2 |
| 289 | 18.95 | 16.65 | 2.30 | 289 | 28.4 | 22.4 | 6.0 |
| SL 50 | 18.05 | 15.70 | 2.35 | SL 50 | 33.4 | 24.2 | 9.2 |
| LSD 5% | 0.32 | 1.01 | | LSD 5% | 2.24 | 4.20 | |

pollinator. A significant interaction between location and pollinators for percent purity was observed. The CT9 hybrids were the highest in purity at Twin Falls, Idaho, but the same hybrids were not the highest in purity at Salt Lake City. A tentative explanation for this interaction between location and pollinators for percent purity is advanced. Apparently the CT9 hybrids, which were comparatively low in amino N but comparatively high in Na and K, are more sensitive to soil salinity than to high nitrogen fertilization.

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# Development of Air Conditioned, Compartmented Greenhouse

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Progress in the development of new methods of plant breeding must, of course, be paralleled by the development of new tools and physical facilities geared to new requirements. As an example, the first hybrid corn seed was produced by laborious and costly hand detasseling; this task was soon taken over by machines developed for the purpose. The discovery and development of male-sterile inbred lines of corn made during the past six to eight years will undoubtedly retire the detasseling machines to obsolescence.

In the field of sugar beet breeding, transition from the use of mass selection techniques to the more detailed procedures involved with inbred lines and cytoplasmic male-sterility necessitates major changes in equipment and physical facilities; primarily the need changes from a relatively small number of large sized isolation plots to a large number of small ones. More precise control of pollination, particularly exclusion of "stray" pollen is imperative; stray pollen has little or no competition in the fertilization of cytoplasmic male-sterile plants or relatively sib-sterile inbred lines developed from self-incompatible breeding material; conversely, stray pollen in a group of "mass selected" plants where cross compatibility is the rule, has a minor chance of effecting fertilization. Further than this, plants produced by outpollination in heterogeneous populations are not readily identified since their influence on the total genic complex of the group is proportionately much smaller.

The above problems associated with changes in breeding techniques necessary to produce hybrid sugar beets, together with economic considerations, prompted the development of the first multi-compartmented greenhouse in the United States, specifically designed for such a purpose. Air conditioned chambers of various types have been used in Europe for a number of years;

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however, the requisites and climatic conditions which dictated the design differ markedly in a number of respects from those which prompted the structure described in the following paragraphs. Fortunately, progress in development of new plant breeding procedures has been paralleled by development of new, and perhaps more versatile, structural materials with which it has been possible to meet the needs of a changing program, and to do so at the lowest possible cost. Final design for this particular structure was arrived at after preliminary investigation and study over a period of several years; during this time, advancements in evaporative cooling methods moved rapidly. Engineering data collected by pilot type installations in existing greenhouses at The Great Western Sugar Company Experiment Station at Longmont, Colorado, proved useful in estimating air moving requirements, wet pad area, etc.

Presented here is a general description of the structure and some of the materials used. The glass house itself is of standard design and dimensions as manufactured by a nationally known commercial greenhouse manufacturer and measured over-all 25′3¼″ in width by 78′5⅛″ in length. All structural and glazing members are of extruded aluminum, with the exception of the exposed corners where galvanized iron angles have been used inside for greater strength. Standard, double-strength glass is used and glazed in the usual manner. Compartments inside the glass house are fabricated of extruded aluminum angle and polyethylene plastic film. Cooling is by water evaporation; negative air pressure through the wet pads is provided by vane-axial fans on each end of the subterranean main exhaust duct. Heating is by low pressure steam in aluminum "fin type" radiator with thermostatically controlled motorized valves.

A sketch of a typical cross section through two compartments is shown as Figure 1 with identification of the various parts as described herein.

A more detailed description of some of the features involved, together with specifications follows:

*Compartments:* A total of 15 compartments, each 10′2⅝″ x 5′2¼″ and 7′ high, are along each side of the center walk within the standard glass house. Sidewalls, fronts, and tops of these compartments are made by stretching .004″ thick polyethylene film on a frame of 1″ x 1″ x 3/16″ extruded aluminum angle. Cleats of flat ½″ x ⅛″ aluminum and aluminum stove bolts hold the film stretched in place. Front and sides rest upon rot-resistant redwood lumber, buried a few inches into the soil.

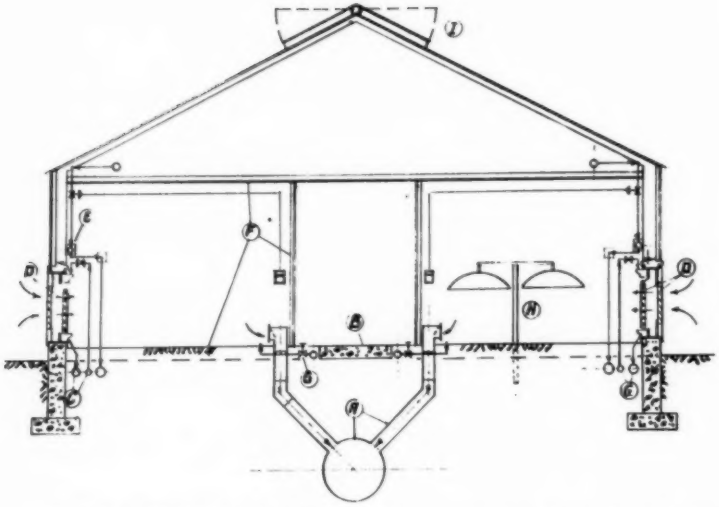

**Figure 1.—Typical cross section of compartmented greenhouse—constructed 1959, Great Western Sugar Company.**

**A. 30.5″ diameter main exhaust duct and 6″ x 30″ rectangular risers to dampered register face in each of the 30 isolated compartments.**

**B. Cement walkway 36″ wide on building centerline.**

**C. Evaporative cooling system complete with sump, pump, automatic make-up, and gravity return.**

**D. Aspen cooling pad 34″ x 24″ x 2″ complete with 4″ gutter water distributor and collector, all made up in 30 wall frames complete with dust stop filters 20″ x 25″ x 1″. Frames become an integral part of concrete foundation wall.**

**E. 15 lb./0″ ga. steam heating, using 2″ aluminum fin tube x 4′ 0″ long per compartment, thermostatically controlling 3 compartments at one time.**

**F. 30 compartment partitions set from 1″ x 3/16″ tee and bar extruded aluminum and separated by .004″ polyethylene front, top and side walls. 10′ x 5′ x 7′ high.**

**G. Closed comparment irrigation system.**

**H. 18″ dome type reflectors for incandescent artificial light.**

**I. Ridge type ventilators.**

**J. Greenhouse structure 25′ x 78′ connected to a headhouse 12′ x 29′.**

*Heating system:* Heat is supplied by low pressure steam (15psi max.); 2″ aluminum "fin type" radiation with one 4′ section in each compartment. Thermostatic control of motorized valves are arranged in such fashion that three compartments are controlled by one thermostat located in the center compartment.

Steam enters from above the first compartment in each set of three and condensate drains out underground from opposite end of each bank of three radiators.

*Cold water supply to evaporative pads:* Water is recirculated by means of a standard type ½ H.P. self-priming, centrifugal pump. Make-up water is automatically introduced into sump by means of a float valve. Drip from aspen pad evaporators is returned underground to sump. Inhibitory chemicals, obtainable from floral supply merchants, are used to prevent growth of algae and undesirable odors in cold water system. The aspen pads used are 34″ wide, 24″ high and 2″ thick.

*Air ducts:* A 30-inch diameter main exhaust duct is buried beneath the center walkway (Figure 1). Flat ducts, with adjustable louvers, leading from each small compartment to the main duct are 6¼″ x 2′6¼″. Air movement is accomplished by two vaneaxial fans, one at each end of the main duct which is discontinuous at the approximate center. Of the fifteen compartments on each side of the walkway, seven are ducted to one fan and eight to the opposite. Fan specifications are (a) 8230 CFM at 5000′ elevation and 70° temperature. (b) 1¼″ static pressure. Pollen in the entering air is screened by commercial type dust stop filters, size 20″ x 25″ x 1″, placed in the airstream ahead of the aspen evaporative cooler pad.

*Irrigation of plants:* When the compartments are closed and sealed at pollination time, the plants are irrigated in furrows from a spigot opening inside the compartment but operated from center walk area.

*Supplemental light:* Supplemental light within each compartment is supplied by two 150 watt incandescent bulbs in 18″ dome-type reflectors, on one central post, but arranged for vertical movement as plants increase in height. Power for lights is supplied from below ground by use of direct burial type cable. Control is from outside the compartment. Lights are completely removable from the compartment to facilitate soil preparation.

*Operational:* The standard greenhouse used has no side opening ventilators but does have full length ventilators at the ridge. Use of *exhaust* fans to provide air movement appears to reduce turbulence inside the compartment and promotes stratification of the air with respect to temperature. This phenomenon is considered advantageous for it reduces in size the mass of air to be cooled inside the compartment while simultaneously providing the desired climate in the space immediately surrounding the growing plants. Air temperatures taken vertically at

Table 1.—Air Temperature Gradient Vertically Inside Compartment

| Height Above Surface | Outside Air Temperature | |
|---|---|---|
| | 85° F. | 94° F. |
| 0 | 66° | 78° |
| 2 ft. | 70° | 81° |
| 4 ft. | 72° | 86° |
| 5 ft. | 78° | 94° |
| 6 ft. | 96° | 106° |

two-foot intervals inside the compartment, with full midday sunlight and no shading of the greenhouse glass by whitewash or otherwise, are given in Table 1. Sugar beet plants were growing within the compartment at time of measurement.

It would appear that the portion of beet seed stalk that might grow beyond the 5′ height would be at such a stage of development that warmer temperatures at that level would not induce adverse effects. It appears entirely feasible, in the climate in northern Colorado at an altitude of 5000′, to utilize each compartment for growing at least two crops of breeders' seed per year, and to do so under very closely controlled and supervised conditions as opposed to space isolation with its inherent danger of loss of plants and greater cost.

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# Meiosis in an $F_1$ Hybrid Between a Turkish Wild Beet (Beta Vulgaris, ssp. Maritima) and Beta Procumbens

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## Introduction

Hybrids between *Beta vulgaris* L. and species of the section *Patellares* Tr. are usually lethal and die in the seedling stage. Viable hybrids are very rare. The first hybrids to survive, obtained by Gaskill (9) from Swiss chard (*B. vulgaris*) X *B. webbiana* Moq. (hereafter referred to as "the webbiana hybrids") and the first hybrids obtained by Oldemeyer (24), were completely sterile. Coe's lethal hybrids (3), preserved by grafting, were also sterile, but Johnson (13) succeeded in obtaining some seed by grafting similar lethal hybrids.

One viable semi-fertile hybrid plant was obtained by Stewart (35), but its backcross progeny survived only until the second generation. Another viable semi-fertile plant obtained by Oldemeyer and Brewbaker (25) from crosses of a Turkish wild beet (*B. vulgaris*) X *B. procumbens* Chr. Sm. (hereafter referred to as "the procumbens hybrid") produced backcross progeny for several generations.

The purpose of hybridization of *B. vulgaris* with nematode-resistant wild beets is for the introduction of resistance to the sugar beet nematode (*Heterodera schachtii* Schmidt).

Meiosis was studied in two hybrid matings: the sterile "webbiana hybrids" (Swiss chard X *B. webbiana*) (33) and the semi-fertile "procumbens hybrid" (Turkish wild beet X *B. procumbens*). Both $F_1$ hybrids arose from hybridization of two diploid species and contained 18 chromosomes (9 chromosomes from *B. vulgaris* and 9 from *B. webbiana* or *B. procumbens*, respectively). Meiosis was studied to reveal the causes of sterility or partial fertility in these hybrids, as well as the possibility of association of chromosomes from different species in these remote $F_1$ hybrids. Chromosome association and crossing-over are important for the transmission of genes responsible for nematode resistance.

## Materials and Methods

Floral axes of the $F_1$ hybrid plant (Turkish wild beet X *B. procumbens*) were fixed in chrom-aceto-formol, dehydrated, em-

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bedded in paraffin and sectioned. Slides were stained by iron hematoxylin. Camera lucida drawings and photomicrographs are presented.

## Experimental Results

### Chromosome Pairing

Chromosomes of *B. vulgaris* associated to some extent with chromosomes of *B. procumbens*. The number of bivalents varied in different cells from 0 to 5. (Figures 1, 2). The grade of pairing in the semi-fertile hybrid (Turkish wild beet X *B. procumbens*) was but a little higher than in the sterile "webbiana hybrids." The majority of pollen mother cells (P.M.C) in the "procumbens hybrid" contained four bivalents instead of three as in the "webbiana hybrids" (Table 1). The chiasma frequency per P.M.C. was estimated at 3.04 for the sterile "webbiana hybrid" and at 3.6 for the semi-fertile "procumbens hybrid," but there were more bivalents with interstitial chiasmata in the "procumbens hybrid" that could provide for interchanges of longer sections of chromosomes. In some cases it was possible to observe the intercrosses of two chromatids in the bivalent.

**Table 1.—Distribution of Bivalents in P.M.C. of an $F_1$ Hybrid (Turkish Wild Beet X *B. procumbens*).**

| Number of bivalents | 0 | 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|---|
| Number of P.M.C. | 3 | 3 | 5 | 17 | 22 | 3 | 53 |
| Percent of P.M.C. with corresponding number of bivalents | 5.7 | 5.7 | 9.4 | 32.0 | 41.5 | 5.7 | |

**Figure 1. (left)—Diakinetic nucleus with $4_{II}$ and $10_I$; three univalents with attenuated constriction area X 3100. Figure 2. (center)—Diakinetic nucleus with $5_{II}$ and $7_I$ plus 2 fragments; one univalent with attenuated constriction X 3100. Figure 3. (right)—Bivalent with intercrossed chromatids X 3100.**

This observation indicates that crossing over really occurred between chromosomes of the different species (Figure 3).

**Chromosome Breakage**

In the prophases of meioses breakage of chromosomes was observed. The pattern of chromosome breakage was similar to that caused by radiation, chemical treatment, or to that which occurs spontaneously. Breakage of chromosomes may occur at any stage including the resting stage. The breaks can be distributed at random or localized at special areas. Ford (7) observed a random distribution of chromosome breaks in *Vicia faba* after treatment by mustard gas and Tjio (36) after treatment by pyrogallol. Special sensitive regions of chromosomes have been indicated by other authors. Koller (17) found in *Tradescantia* that the centromere and the adjacent region were susceptible. Jackson and Barber (12) indicated that the most sensitive region in *Tradescantia* was near terminal regions of chromosome arms, the centromere regions were less susceptible and the mid-arm regions were resistant. Rees and Thompson (28) found in an inbred line of rye that the breakage was localized mainly towards the ends of the chromosomes, agreeing with the distribution of chiasmata. The controversies in the localization of breaks observed in different experiments and in different plants were elucidated by the recent investigations of Lane (18), Haque (11) and Sparrow (34) who showed that physiological conditions of the cell and nucleus interaction with the type of treatment produce different sensitivity in different parts of the chromosomes.

In the hybrid studied the breaks were located at the centromere region. Some chromosomes at diakinesis showed a very pronounced attenuated constriction area which resembled a thin thread. One to three chromosomes in some nuclei exhibited such elongated constriction. Figures 1 and 2 show several chromosomes in the nuclei, the arms of which are connected by the thin thread only. The same appearance was observed in meiosis of $F_1$ "webbiana hybrids" (33). In these hybrids the chromosomes with attenuated constrictions were observed only occasionally, while in the hybrid with *B. procumbens* such chromosomes appeared with comparatively high frequency.

The fragmentation occurred by transversal breakage of the thin thread. The breakage was always symmetrical; it affected both chromatids at the same points and occurred always in the region adjacent to the centromere or through the centromere itself. The breakage of the chromosomes in the "procumbens hybrid" belonged to the chromosome type (B″), not to the

chromatid type, because the break occurred through the centromere region which is not divided at prometaphase and the break affected both chromatids symmetrically.

The same type of fragmentation was observed in several plants after treatment by narcotics. Kihlman and Levan (16) and Tjio (36) observed it in *Vicia faba,* Ostergren (26) and Levan and Tjio (20) in *Allium cepa.* Spontaneous breakage of chromosomes was described by Levan and Lotfy (19) in *Vicia faba,* by Muntzing (22) in rye, by Muntzing and Nygren (23) in *Poa alpina,* by Darlington (4) in *Tradescantia,* by Darlington and Wylie (6) in *Narcissus* and by Hair (10) in *Agropyron.*

Not only the univalents but sometimes the broken bivalents could be observed at prometaphase. In Figure 4 a bivalent with terminal chiasma is shown. One partner of the bivalent is fragmented at the constriction area and the fragment (one broken arm) is located at the opposite side of the bivalent.

**Figure 4. (left)—Fragmentation of chromosomes; 2 chromosomes with attenuated constriction, 1 univalent and 1 bivalent fragmented X 3100. Figure 5. (center)—A dicentric bridge at anaphase X 3100. Figure 6. (right)—A bridge and a lagging bivalent (non-disjunction) at anaphase X 3100.**

Some fragments were eliminated, but others reunited immediately. In several cells at the first anaphase the bridges which were formed by the chromatids of telocentrics united by their distal ends were observed (Figures 5, 6). These dicentric bridges were thin, stretched on the spindle and pulled out by their centromeres. The point of the reunion of the chromatids was always noticeable and attenuated like a constriction because of the resistance offered by the bridge to the anaphase pulling.

Acentric fragments were rarely observed. Sometimes partly eliminated small fragments were revealed in the plasm outside of the nuclei. It is most probable that the acentrics were not

located on the spindle area but were pushed out to the periphery of the nuclei toward the nuclear membrane. After the disappearance of the membrane, the acentrics were thrown out into plasm and eliminated immediately. It is less probable that the sister reunion in the acentrics made them indistinguishable from the lagging univalents, or the attraction to the ends of other chromosomes made them invisible.

In one cell the "trivalent" bridge (probably tricentric $C_3$) was observed (Figure 7). The bridge was formed by three united chromatids, at least one of which belonged to another fragment (non-sister reunion). One of the three fragments reached the anaphatic group of chromosomes, the others remained on the spindle. The same kind of chromatid reunion was observed by Ostergren (26) in *Allium cepa* after coumarin treatment.

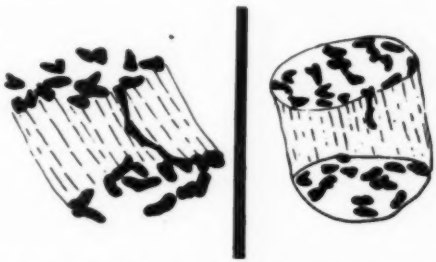

**Figure 7. (left)—A "trivalent" bridge at anaphase X 3100. Figure 8. (right)—A lagging iso-chromosome X 3100.**

Sometimes the iso-chromosomes with two arms of equal size connected by a constriction (centromere) were found moving on the spindle at the first anaphase. Figure 8 shows a belated iso-chromosome almost reaching the telophatic group of chromosomes at the time the nucleus had already been formed. Its lagging position close to the polar group of chromosomes may be caused either by the incompleteness of its centromere and insufficient poleward attraction or by the delay in the division of the telocentric from which it arose. The functional capacity of an iso-chromosome will depend on the number of centromeric chromomeres which the telocentric received after misdivision. If the break occurred through the central region of the centromere, the sister reunion within this region will give rise to the functional iso-chromosome (5).

There is no doubt that the unstable telocentrics could be formed with comparatively high frequency in the type of breakage observed, and they may lead, according to Sanchez-Monge (32), to the formation of iso-chromosomes with functional centro-

meres. Such iso-chromosomes could reach the poles and be included in the daughter nuclei. There is no doubt that when the breaks are localized at the centromere region more iso-chromosomes are formed than are observed. Not all iso-chromosomes, even with complete and functional centromeres, will reach the poles; some of them will be delayed because of the delay in division of some telocentrics and the formation and orientation of iso-chromosomes or because of different hazards. But just such iso-chromosomes, lagging or moving on the spindle at the late anaphase, have more chances to be detected than the iso-chromosomes which moved together with other chromosomes and were included in the nuclei.

The percentage of cells at diakinesis containing chromosomes with attenuated constrictions was relatively high. From 270 cells 120 cells, or 44.4 percent, contained fragments or chromosomes with very thin fiber-like constrictions, but the number of cells with fragments and bridges at the first anaphase equaled only 10 percent. From 280 cells at this stage the bridges and fragmented chromosomes were found in 28 cells. It can be assumed that 10 percent of the cells exhibited broken chromosomes at the first meiotic division. Obviously not all the chromosomes which showed attenuated constriction at diakinesis were later fragmented. Actually the chromosomes with an attenuated constriction region were observed sometimes at the first metaphase. But the constriction area, although distinctly separating the two arms of the chromosomes, was not so attenuated as at diakinesis (Figure 9). Probably the metaphatic contraction shortened the elongated constriction area in some chromosomes and enabled them to pass through metaphase and anaphase without breakage.

It is also probable that some of the broken chromosomes were not detected at anaphase because of their restitution in the original way, but in such cases the elongated centromere area had to be contracted anyway.

The fragmentation of the bridges was not observed. The majority of bridges remained on the spindle after the telophase nuclei were formed. The telophase bridges connecting the resting nuclei were revealed in several cells (Figure 10). Although some lagging fragments were observed on the spindle at the first anaphase, the others which succeeded in reaching the poles were included in the microspores and gave rise to structural aberrations.

In the second division the broken chromosomes were rarely observed. In such cases one of two daughter nuclei exhibited at the second anaphase a bridge sometimes accompanied by two

little acentric chromatids (Figure 11). The breakage might occur in this case at the interphase. The attenuated constrictions were indeed observed in some interkinetic nuclei.

Breakage of chromosomes was observed in some interspecific and interlinear hybrids. Bernstrom (2) observed inverted bridges in the interlinear hybrids of *Lamium amplexicaule*. Ribbands (29) described the breakage of chromosomes and the formation of inversion and translocation bridges in *Lilium* X *testaceum*.

Usually the chromosome breakage in interspecific hybrids is caused by translocations or by inversions followed by crossing over between inverted and non-inverted segments of chromosomes. As a result inversion and translocation bridges are formed. In the hybrid Turkish wild beet X *B. procumbens* the breakage of chromosomes was spontaneous and similar to that caused by chemicals or radiation. The disturbance of genetic balance and of the cell metabolism may be a possible explanation of this process.

**Figure 9. (left)—Chromosomes with shortened constriction at prometaphase X 3100. Figure 10. (center)—A telophatic bridge X 3100. Figure 11. (right)—Second anaphase; bridge and 2 acentrics in one nucleus X 3100.**

## First Meiotic Division

At metaphase all chromosomes were arranged in the equatorial plate. The bivalents as well as the univalents were distributed at random. Univalents often occupied the central part of the plate while the bivalents showed a tendency to lie at the periphery. Congression of the chromosomes was fair.

It is very characteristic of the "procumbens hybrid" that the first meiotic division in this hybrid is rather regular. In many cells the bivalents divided and their partners proceeded to the respective poles. Several univalents divided in the first division too. In some P.M.C. all the univalents divided in the first division. Division of some univalents in the first division was observed by von Rosenberg (30) in different species of *Hieracium*, by Mather (21) in the triploid wheat hybrids, by Kihara and

Nishiyama (15) in the hybrids *Triticum palonicum* X *Haynaldia villosa*, by Akerman and Hagberg (1) in oats hybrids, by Gaewski (8) in some *Geum* hybrids, by Savitsky (33) in the "webbiana hybrids." But in the hybrid Turkish wild beet X *B. procumbens* the division of univalents showed a higher manifestation.

The chromosomes in this hybrid were not scattered over the spindle, but in many cells they reached the poles simultaneously. The univalents which divided at the same time as the bivalents reached the poles together with them (Figures 12a, b, c, d).

On the other hand, the pictures of disturbances usual for interspecific hybrids were observed in other P.M.C. (Figures 13a, b). In some cells non-disjunction and lagging of bivalents were observed at the anaphase and at interkinesis (Figures 5

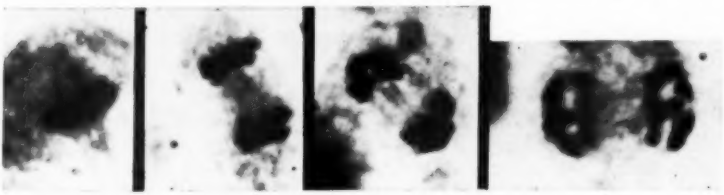

**Figure 12.—Regular first meiotic division X 2034; (left)—First metaphase, side view. (left center)—Late anaphase, all the chromosomes at the poles. (right center)—Telophase without laggards. (right)—Interkinesis without laggards.**

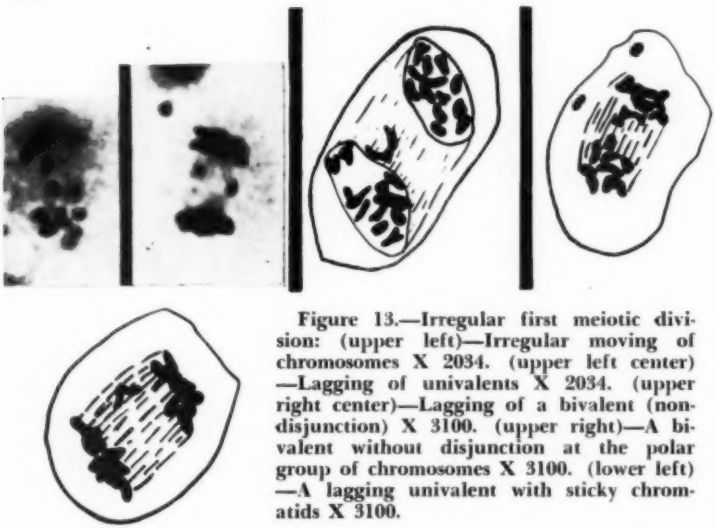

**Figure 13.—Irregular first meiotic division: (upper left)—Irregular moving of chromosomes X 2034. (upper left center) —Lagging of univalents X 2034. (upper right center)—Lagging of a bivalent (non-disjunction) X 3100. (upper right)—A bivalent without disjunction at the polar group of chromosomes X 3100. (lower left) —A lagging univalent with sticky chromatids X 3100.**

and 13c). Sometimes the bivalents (without disjunction) reached the polar group of chromosomes and might be included in the nucleus (Figure 13d). Some univalents in which the separation of chromatids was delayed remained on the spindle while other chromosomes reached the poles. Their centromeres divided, but the chromatids were stuck together in the region close to their distal ends (Figure 13e). Some of the univalents passed to the poles undivided.

Laggards and chromosomes thrown out into plasm were observed in the first division in only 18 percent of the P.M.C. Eighty-two percent of the cells did not contain lagging chromosomes. This confirms also the regularity of the first meiotic division.

**Table 2.—Number of Chromosomes in P.M.C. after the First Meiotic Division in an $F_1$ Hybrid (Turkish Wild Beet X *B. procumbens*).**

| Number of chromosomes in P.M.C. | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of P.M.C. containing corresponding chromosome number | 5 | 3 | 0 | 5 | 2 | 6 | 2 | 4 | 1 | 2 | 2 | 1 | 0 | 4 | 37 |

The number of chromosomes in P.M.C. at the first anaphase and at interkinesis varied from 23 to 36 (Table 2). In the majority of cells 23 to 30 chromosomes were observed instead of the 18 chromosomes which are normally expected in a diploid at this stage. This means that there were 5 to 18 chromosomes in excess. These excess chromosomes were derived from univalents which divided in the first division.

Because of successful division and distribution of univalents, the interkinetic nuclei contained a high number of chromosomes (Table 3). Instead of 9 chromosomes in a diploid plant they contained 10 to 18 chromosomes. The majority of nuclei had

**Table 3.—Number of Chromosomes in the Interkinetic Nuclei of an $F_1$ Hybrid (Turkish Wild Beet X *B. procumbens*).**

| Number of chromosomes in the interkinetic nuclei | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Number of nuclei containing corresponding chromosome number | 5 | 3 | 11 | 11 | 15 | 7 | 8 | 5 | 8 | 73 |

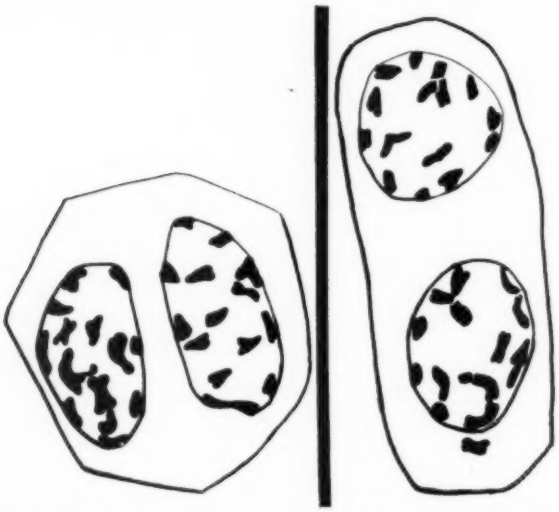

**Figure 14. (left)—Interkinetic nuclei with 14:14 distribution X 3100. Figure 15. (right)—Interkinesis, 15:15 distribution: one nucleus with 15, another with 14 chromosomes and 1 chromosome in plasm. Derived from division of all chromosomes in the nucleus containing $3_{II}$ plus 12, X 3100.**

12, 13 and 14 chromosomes. In some P.M.C. the distribution of chromosomes between two interkinetic nuclei was equal, for instance, 12:12, 13:13, 14:14 18:18 (Figures 14, 15). In the 14:14 distribution the 4 bivalents and all 10 univalents proceeded to the respective poles regularly. A distribution of 13:13 could occur when there was $3_{II}$ and $12_{I}$ in the P.M.C. The 3 bivalents and 8 univalents divided and proceeded to the opposite poles. Of the remaining 4 univalents 2 moved undivided to 1 pole and 2 to another. The P.M.C. with the same number of bivalents, 3, and univalents, 12, could give rise to interkinetic nuclei with a 12:12 distribution in a case when from $12_{I}$ only 6 divided and proceeded to the opposite poles and from the remaining $6_{I}$, 3 undivided univalents reached one pole and 3 others reached another pole. Different numbers of chromosomes in interkinetic nuclei showing equal distribution are conditioned by different numbers of bivalents and different numbers of divided univalents in corresponding P.M.C. The lagging chromosomes and the unequal distribution of undivided univalents will change, of course, this equal distribution and interkinetic nuclei will occur with 12:13, 12:15 and other chromosome distributions.

Some P.M.C. contained at interkinesis 2 nuclei with 18 chromosomes in each (Figure 16a, b, c). Such nuclei arose in

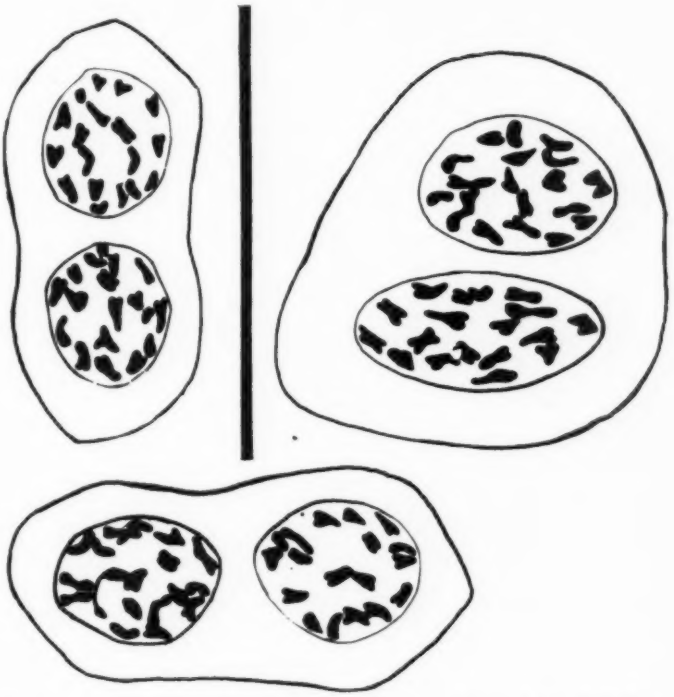

**Figure 16.—a (upper left), b (upper right), c (lower left). P.M.C. containing 2 restitutional nuclei with 18:18 distribution at interkinesis X 3100.**

the asynaptic P.M.C. with 18 univalents all of which divided and their chromatids proceeded to the opposite poles. Although the chromosomes in such nuclei showed split ends as usual at interkinesis, most of them did not undergo the second division. Occasionally the cells with one large restitutional nucleus containing 18 chromosomes were also observed at diakinesis (Figure 17).

**Second Meiotic Division**

In the second metaphase and anaphase a few chromosomes divided. The division and separation of the chromosomes were irregular, the chromosomes were scattered over the spindle and did not reach the poles at the same time (Figure 18). More lagging chromosomes were observed in the second division than in the first. In the tetrad stage only 17.5 percent of the cells did not contain chromosomes lagging in the cytoplasm.

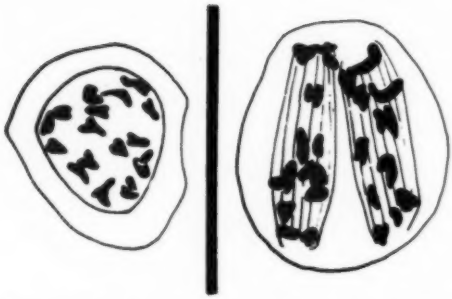

**Figure 17. (left)—P.M.C. containing restitutional nucleus with 18 chromosomes at interkinesis X 3100. Figure 18. (right)—Second anaphase; irregular moving of chromosomes X 3100.**

The number of chromosomes in P.M.C. at the second anaphase and in the tetrad stage varied from 27 to 42 (Table 4). The majority of cells contained 33 to 36 chromosomes. If we compare the number of chromosomes in P.M.C. after the first division (where the number of chromosomes in the cells did not exceed 36) with the number of chromosomes after the second division, it is obvious that in the second division most of the chromosomes which divided were partners of bivalents and the univalents which did not divide in the first division. Only a few univalents divided the second time.

The number of chromosomes after two divisions cannot exceed the somatic number of chromosomes unless some chromosomes divide equationally the second time. In the hybrid studied some P.M.C. at the tetrad stage contained 41 and 42 chromosomes providing that some univalents divided again in the second division.

The number of chromosomes in the nuclei at the tetrad stage varied from 1 to 20 (Table 5). In the majority of nuclei the number of chromosomes was lower than 9, but some nuclei carried a haploid, 9, and a diploid, 18, number of chromosomes.

In the tetrad stage in some locules of anthers normal tetrads with 4 nuclei prevailed; some P.M.C. contained 5 nuclei (pentads). In other locules most P.M.C. consisted of hexads or contained 7 or 8 nuclei. Rarely did the number of nuclei reach 10. The size of nuclei varied greatly depending on the number of chromosomes. In many sections of locules 1 to 3 dyads and sometimes a triad could be observed (Figure 19). The nuclei in dyads usually contained 9, 12, 13, 14, 15 and 16 chromosomes, i.e., the number of chromosomes typical of the interkinetic nuclei. This chromosome number indicates that in some P.M.C. the

Table 4.—Number of Chromosomes in P.M.C. after the Second Meiotic Division in an $F_1$ Hybrid (Turkish Wild Beet X *B. procumbens*).

| Number of chromosomes in P.M.C. | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of P.M.C. containing corresponding chromosome number | 2 | 3 | 3 | 2 | 2 | 3 | 7 | 5 | 6 | 4 | 1 | 1 | 1 | 1 | 2 | 1 | 44 |

Table 5.—Number of Chromosomes in the Nuclei at the Tetrad Stage in an $F_1$ Hybrid (Turkish Wild Beet X *B. procumbens*).

| Number of chromosomes in the nuclei at the tetrad stage | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of nuclei with corresponding chromosome number | 4 | 20 | 9 | 11 | 13 | 20 | 28 | 23 | 13 | 8 | 6 | 7 | 6 | 2 | 2 | 2 | 2 | 5 | 2 | 2 | 185 |

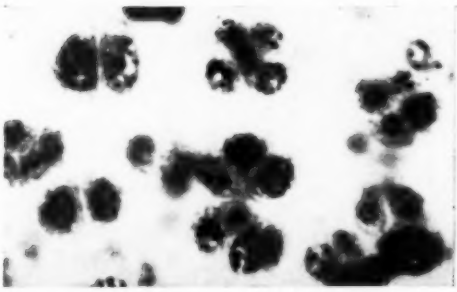

**Figure 19.—Locule of anther containing dyads, tetrads, pentads, etc. X 1079.**

second division did not take place. The same appearance which was highly expressed in the "webbiana hybrids" is only slightly expressed in the "procumbens hybrid." In some dyads the nuclei contained higher chromosome numbers.

What gametes of $F_1$ hybrids were really viable can indicate the number of chromosomes in the first backcross progeny ($F_1$ X 2n *B. vulgaris*). All first backcross hybrids were triploids or aneuploids approaching to triploids. They contained 26, 27, 28 and 30 chromosomes. Most of the hybrids were triploids with 27 chromosomes. They arose from asynaptic restitutional nuclei with 18 chromosomes. The plants with 26, 28 and 30 chromosomes arose from gametes which carried 17, 19 and 21 chromosomes, correspondingly.

The gametes with 17 chromosomes could arise from an asynaptic cell in which 17 of 18 univalents divided and proceeded to the respective poles and 1 univalent moved to either pole undivided, or if 2 undivided univalents proceeded to 2 different poles. Gametes with 17 chromosomes could originate also from the cells with 1 bivalent if the partners of the bivalent and the chromatids of 16 divided univalents proceeded to different poles or in the case of non-disjustion when 1 bivalent reached one pole undivided while 16 univalents divided and proceeded to different poles.

The origin of gametes carrying 19 and 21 chromosomes can be explained only by the assumption that the second division started in some of the restitutional nuclei, but this division was not complete (because of the incompleteness of the spindle) and after a certain number of univalents divided the whole set of chromosomes was included in one nucleus. In cases where gametes carried 19 chromosomes, 1 chromosome of 18 had to divided the second time. In cases of 21 chromosomes, 3 of 18 chromosomes in the restitutional nucleus divided the second time.

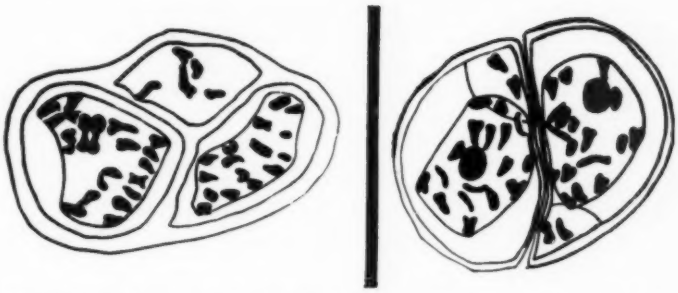

**Figure 20. (left)—A triad with 20 chromosomes in one nucleus, 16 chromosomes in another and 5 chromosomes in plasm, derived from second incomplete division in both restitutional nuclei X 3100. Figure 21. (right)—A dyad containing 18 chromosomes in each nucleus and 4 chromosomes in plasm, derived from incomplete second division in both restitutional nuclei X 3100.**

In the locules of anthers at the tetrad stage one could observe dyads or triads, the nuclei of which contained 19, 20 and 21 chromosomes. Figure 20 represents a triad with 20 chromosomes in one nucleus, 16 in another and 5 chromosomes thrown in the plasm which formed a little cell without formation of a nucleus. This triad arose from interkinetic P.M.C. containing 2 restitutional nuclei with 18 chromosomes in each. In the first nuclei 2 chromosomes divided the second time, but because of incompleteness of the second meiotic division they remained in the same nucleus. In the second nucleus 3 chromosomes divided a second time giving rise to 21 chromosomes from which 16 remained in the nucleus and 5 were thrown in the plasm. In Figure 21 a dyad is shown in which the second division started in both restitutional nuclei. In both nuclei 2 chromosomes divided the second time giving rise to 20 chromosomes from which 2 were thrown into plasm and formed little cells in both components of the dyad. Both restitutional nuclei contained 18 chromosomes as before, but in 1 nuclei among 18 chromosomes 4, and in another 2, thin chromosomes could be observed. These thin chromosomes certainly represent the chromatids derived after the second division of univalents. The chromosomes thrown into cytoplasm were not the chromosomes which underwent the second division. The division of a chromosome and its orientation and movement on the spindle and, consequently, the possibility of being eliminated in the plasm are independent processes. The division of a chromosome is an autonomous process stipulated by the division of the chromonema and of the centromere, while the movement on the spindle is conditioned by the

orientation of centromeric chromomeres of its centromere. Consequently, the gametes with 18 chromosomes which arose from restitutional nuclei will not always carry 9 chromosomes of *B. vulgaris* and 9 chromosomes from wild species. Their chromosome set may include some homologous chromosomes of either species.

In this way all the offspring of $F_1$ plants were obtained from gametes which arose from the asynaptic restitutional nuclei.

## Conclusion and Discussion

The somewhat higher degree of chromosome pairing and higher chiasma frequency in the semi-fertile hybrid Turkish wild beet X *B. procumbens*, as compared with the sterile "webbiana hybrids," could not be responsible for the higher fertility.

The semi-fertility of the hybrid with *B. procumbens* was due to a rare and important pecularity—the formation of restitutional nuclei because of the regular division and distribution of univalents.

Formation of restitutional nuclei was described by von Rosenberg (30, 31) for *Hieracium laevigatum, H. lacerum* and *H. boreale*, and by Karpechenko (14) for *Raphano-brassica* hybrids. Restitutional nuclei were formed in *Hieracium* species: (a) when the nucleus entered interkinesis directly from diakinesis without formation of the spindle and (b) because of variation of "semi-heterotypic division" when the spindle disappeared after the univalents were distributed between the poles and the whole set of chromosomes was surrounded by the nuclear membrane.

In *Raphano-brassica* hybrids obtained by Karpechenko restitutional nuclei were formed because the incomplete development of the spindle prevented distribution of the univalents between poles at anaphase and the whole set of chromosomes was included in one nucleus.

The hybrids between the Turkish wild beet and *B. procumbens* revealed a new way by which restitutional nuclei may be formed, namely, by the regular division in an asynaptic P.M.C. of all the univalents during the first meiotic division.

The best explanation of the way by which the univalent may divide in the first meiotic division was given by Ostergren (27). According to his hypothesis the poleward factor -a may change the one-sided localization of centromeric chromomeres in the centromere of the univalent into the opposite one. Polarization of the centromeres leads to auto-orientation of the univalent and sufficient poleward attraction pulls the daughter chromatids

connected only by the interior zone of the centromere to the opposite poles.

Only diploid gametes containing a complete haploid set of chromosomes of both species involved in hybridization or the gametes with the number of chromosomes approaching to it were viable. Haploid gametes with 9 chromosomes were not viable because of the composition of their chromosome set. They contained variable numbers of chromosomes from both species, but this number was always much lower than the haploid number of either species, for instance, 4 chromosomes from one species and 5 chromosomes from another. Therefore, their physiological activity was limited.

Hybrids derived from two diploid species were unable to survive on the diploid base. To produce progeny the hybrids themselves increased the number of chromosomes and shifted to a higher ploidy level.

The origin of the first-backcross generation from the restitutional gametes leads to an important conclusion that in spite of the possibility of crossing over between associated chromosomes of different species and transmission of genes which provide for nematode resistance from wild species to the chromosomes of *B. vulgaris*, the progeny of the $F_1$ plant carried the chromosomes of wild beets, but not the chromosomes with segmental interchanges. This does not mean, of course, that the segmental interchanges between the chromosomes of different species may not occur in the next hybrid generation.

To overcome the barrier of sterility in interspecific hybrids between *B. vulgaris* and species of section *Patellares* it might be desirable to obtain hybrids on a higher ploidy level.

Acknowledgment: I am indebted to Drs. R. K. Oldemeyer and H. E. Brewbaker for fixed flower buds of the $F_1$ hybrid which they sent me for the investigation.

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# Preparation and Storage of Beet Pulp Samples for Sucrose Analysis

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The practice of freezing sugar beet pulp and analyzing it later for sucrose content has facilitated greatly the harvesting of sugar beet plants in physiological studies. Cormany (2)[2] observed little to no change between fresh and frozen pulp stored in metal and paper containers for a period of 12 weeks at —15° F. and Price and Fife (3) found the same to be true for pulp stored in glass containers for 15 months at —5° to +8° F. In the present study their techniques have been modified to eliminate the mixing and weighing of frozen pulp, polyethylene bags were substituted for bulky metal and paper containers and dry ice was used for quick freezing. A relatively broad base for the test was provided by storing pulp ranging in sucrose concentration from 8.6 to 16.0%. Within these limits the storage of pulp at —2° F. for periods of 0, 3.5, 9, 12, 25 and 32 months had no significant effect upon the sucrose content of the frozen pulp samples. These results and their statistical evaluation are presented in this paper.

## Methods and Procedures

The pulp samples for this study were obtained from the storage roots of sugar beet plants of the US 75 variety that had been grown outdoors in a uniformity trial as single beets per 5-gallon pot filled with vermiculite. The plants were watered daily with modified ½ strength Hoagland's solution (5) throughout the growing period from May 18 to October 26, 1954. At the time of harvest the beet roots were washed free of vermiculite, dried with a towel and a V-shaped wedge removed from the roots by means of a Kiel rasp. The pulp from an individual beet root was mixed thoroughly with a spatula and two 26.0 gram samples were weighed for analysis. Each 26.0 gm sample was placed immediately into a 4″ X 2″ X 4″ polyethylene bag of 1.5 mil thickness, sealed with a heat sealer and frozen immediately by placing the sealed bag in direct contact with dry ice. After the samples were quick frozen, they were placed into a deep freeze cabinet maintained at —2° F. for storage. Sucrose was determined by thoroughly mixing and digesting the frozen pulp sample with 179.1 ml of basic lead acetate for thirty minutes in a covered metal beaker set into a hot water bath at 80° C.

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[2] Numbers in parentheses refer to literature cited.

After cooling to 20° to 23° C, the mixture was shaken vigorously, filtered and the percent sucrose in the filtrate determined in a saccharimeter (1).

A total of 150 beets were sampled in duplicate as described above. The first member of each pair of samples was analyzed for sucrose within one week after the samples were frozen. The results of these analyses constitute the "initial" values. At the end of each storage period, including zero time, 25 samples were selected at random for the "final" sucrose analysis.

A sensitive measure of the effect of storage time on the sucrose concentration of the frozen beet pulp is the difference between the final analysis ($X_f$) and the initial analysis ($X_i$) for each pair of samples. These differences are reported in Table 1 for each sampling period and an analysis of variance of the differences due to storage is given in Table 2. The mean sucrose values, the range in sucrose concentrations, the regression equation for the initial and final analyses, the correlation coefficients, the coefficients of variation, and error variances for each group

**Table 1.—Differences Between Final and Initial Sucrose Analysis ($X_f$ - $X_i$)**

| Sample # | Storage Period in Months | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 3.5 | 9 | 12 | 25 | 32 |
| 1 | 0.0 | +0.1 | −0.2 | +1.1 | −0.2 | +0.2 |
| 2 | −0.1 | −0.1 | −0.1 | −0.1 | 0.0 | +0.1 |
| 3 | +0.1 | +0.1 | 0.0 | +0.1 | 0.0 | 0.0 |
| 4 | −0.1 | −0.7 | −0.1 | +0.1 | 0.0 | −0.2 |
| 5 | −0.1 | +0.2 | −0.2 | −0.6 | +0.1 | −0.1 |
| 6 | −0.2 | +0.3 | +0.1 | 0.0 | 0.0 | 0.0 |
| 7 | +0.1 | −0.1 | 0.0 | 0.0 | −0.1 | 0.0 |
| 8 | +0.2 | −0.2 | −0.1 | −0.1 | −0.2 | +0.1 |
| 9 | 0.0 | +0.2 | −0.3 | −0.1 | 0.0 | 0.0 |
| 10 | −0.1 | 0.0 | +0.2 | −0.2 | −0.1 | −0.2 |
| 11 | −0.1 | +0.1 | −0.1 | −0.1 | −0.1 | −0.1 |
| 12 | 0.0 | −0.2 | 0.0 | −0.9 | −0.3 | +0.1 |
| 13 | +0.1 | 0.0 | +0.2 | −0.6 | 0.0 | +0.3 |
| 14 | −0.1 | 0.0 | 0.0 | −1.1 | −0.1 | +0.2 |
| 15 | −0.1 | −0.1 | 0.0 | −0.1 | 0.0 | +0.2 |
| 16 | +0.1 | 0.0 | +0.1 | −0.1 | +0.2 | 0.0 |
| 17 | −0.1 | +0.3 | −0.3 | −0.1 | −1.2 | −0.3 |
| 18 | 0.0 | +0.5 | 0.0 | +0.1 | −0.1 | 0.0 |
| 19 | 0.0 | +0.1 | −0.3 | −0.1 | −0.3 | 0.0 |
| 20 | +0.2 | +0.2 | −0.1 | −0.1 | −0.1 | −0.1 |
| 21 | +0.6 | 0.0 | −0.2 | 0.0 | −0.1 | +0.2 |
| 22 | +0.2 | +0.1 | 0.0 | −0.1 | +0.3 | −0.1 |
| 23 | −0.1 | +0.1 | +0.1 | +0.1 | 0.0 | +0.4 |
| 24 | −0.1 | 0.0 | −0.1 | −0.2 | +0.3 | −0.3 |
| 25 | +0.1 | −0.7 | 0.0 | −0.1 | +0.1 | +0.2 |
| Mean | +0.020 | +0.008 | −0.056 | −0.128 | −0.076 | +0.024 |

LSD at the 5% and 1% levels are equal to 0.189 and 0.200, respectively.

of 25 pairs of samples are reported in Table 3. The regression of sucrose observed for the 32-month storage period relative to the original values is given in Figure 1 while the sucrose changes in relation to storage time are presented graphically in Figure 2.

Table 2.—Analysis of Variance of Sucrose Differences ($X_f$ - $X_i$)

| Source of Variation | Degrees of Freedom | Sum of Squares | Mean Square[1] | Observed F | Required F | |
|---|---|---|---|---|---|---|
| | | | | | 5% | 1% |
| Total | 149 | 9.7197 | | | | |
| Time | 5 | 0.4781 | 0.0956 | 1.49 | 2.21 | 3.02 |
| Error | 144 | 9.2416 | 0.0642 | | | |

[1] The mean square for error is the pooled error variance of the differences between the final and initial values presented in Table 1 and is equivalent to $s_D^2$(4).

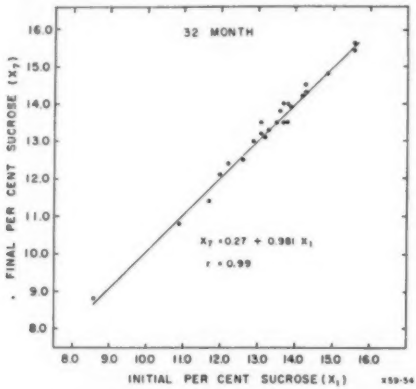


**Figure 1.—Regression of initial and final sucrose percent.**

## Discussion of Results

The differences between the final and initial analyses for the storage periods of 3.5 to 32 months, recorded in Table 1, are in reality the combined effects of sampling and analytical variation (within a pair of duplicate samples) and the effect of storage time on the sucrose content of the pulp. An inspection of these differences for each storage period reveals that the values are relatively constant and differ very little from the results of the initial storage period at time "zero." At zero time the differences are primarily due to sampling and analytical variation and not due to time of storage. The relative constancy of these differences for all storage periods indicates that there is no

Table 3.—Summary of Results

| Storage Time in Months | Sucrose Range Between Pairs % | Mean Sucrose Final % | Mean Sucrose Initial % | Mean Difference $X_f - X_i$ | Regression Equations | Correlation Coefficient r | Standard Deviation $s^1$ | Coefficient of Variation % |
|---|---|---|---|---|---|---|---|---|
| 0 | 11.1-16.0 | 13.43 | 13.41 | +0.02 | $X_2=0.06+1.006X_1$ | 0.99 | 0.12 | 0.88 |
| 3½ | 10.6-15.9 | 13.17 | 13.18 | —0.01 | $X_3=0.17+0.988X_1$ | 0.98 | 0.19 | 1.43 |
| 9 | 11.5-15.7 | 13.60 | 13.66 | —0.06 | $X_4=0.34+0.971X_1$ | 0.99 | 0.10 | 0.73 |
| 12 | 11.5-14.5 | 13.20 | 13.32 | —0.13 | $X_5=0.84+0.928X_1$ | 0.88 | 0.28 | 2.11 |
| 25 | 10.4-16.0 | 13.49 | 13.57 | —0.08 | $X_6=0.31+0.971X_1$ | 0.97 | 0.20 | 1.46 |
| 32 | 8.6-15.6 | 13.33 | 13.32 | +0.01 | $X_7=0.27+0.981X_1$ | 0.99 | 0.13 | 0.96 |
| All values | 8.6-16.0 | 13.37 | 13.41 | —0.04 | $X_f=0.25+0.978X_1$ | 0.98 | 0.18 | 1.34 |

[1]s is the standard deviation of a single determination calculated from the initial and final sucrose values of the pulp samples (4). $2s^2=sn^2$ of Table 2. (4).

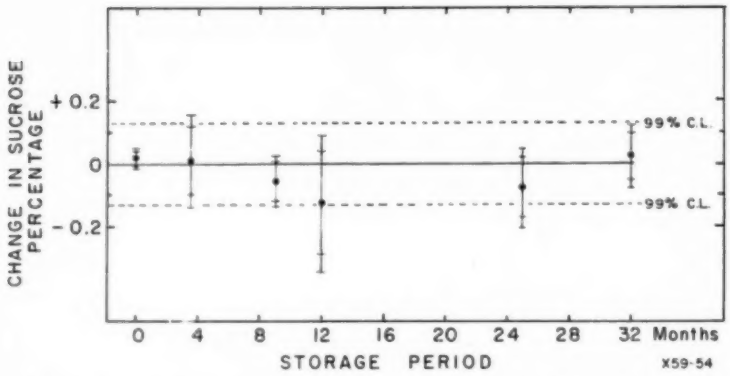


**Figure 2.—Effect of storage on sucrose percentage of sugar beet pulp. The upper and lower limits of the 95% and 99% confidence limits for the mean differences from Table 1 are indicated for each storage period. The horizontal dotted lines are the overall 99% confidence limit about mean 0.**

appreciable loss in sucrose by enzymatic hydrolysis nor an appreciable gain in sucrose from the hydrolysis of polysaccharides nor an apparent gain in sucrose from a loss of moisture during storage. Apparently the variations noted between the final and initial analyses for all storage periods are those due to random variations that are associated with minor differences in technique and not to storage time. An analysis of variance of the differences for the six storage periods supports this hypothesis (Table 2). The F-value for the storage periods given in Table 2 is nonsignificant and this fact indicates that the differences between the final and initial analyses for all storage periods (Table 1) are the same, i.e., the differences were drawn from a single uniform population of differences.

The correlation coefficients (r) for the six storage periods indicate that the degree of correlation between the initial and final sucrose determinations for the pulp samples is very good indeed (Table 3). In all instances the coefficients exceeded 0.96 except for the 12-month period. The decrease in correlation coefficient to 0.88 for the 12-month period indicates that either the time of storage has begun to affect some of the samples more than others or that a difference in technique affected the results or that the readings were in error. The two latter possibilities are most likely the cause of the decline in the correlation coefficient for the 12-month period, since the values for subsequent periods are again high (Table 3) and the differences between

the final and initial sucrose values (Table 1) do not increase. It is to be noted too that the decline in the correlation coefficient for the 12-month period is mainly associated with two large differences, +1.1 and —0.9, which are exceptionally large not only for the 12-month period but for all other storage periods as well. In retrospect an inadequate mixing of the pulp prior to sampling appears to have been the most likely cause for these large differences. Mechanical mixing of the pulp before sampling and a vigorous stirring of the slurry prior to filtration are now stressed in the procedure for determining sucrose in beet pulp samples.

The regression coefficients for the final and initial sucrose concentrations for all storage periods are approximately one except for the 12-month period, which dropped to a value of 0.928 (Table 3). This relatively large decrease in the regression coefficient is again associated with the two large differences +1.1 and —0.9 (Table 1). The finding that the slopes are approximately one indicates that the differences due to technique and in storage time are relatively constant over a range of 8.6 to 16.0 percent for a storage period of 32 months (Figure 1). The standard deviations for a single determination and the coefficients of variation are also relatively constant except for the 12-month period where again the two large differences of +1.1 and —0.9 increased these values (Table 3).

The differences for each storage period have been averaged and plotted about an assumed mean of zero and this is indicated by the solid horizontal line in Figure 2. If a normal distribution of means is assumed, then the 99% limits can be calculated as $0 \pm 2.58 \frac{s_D}{\sqrt{N}}$ which is equal in this instance to $0 \pm 0.131$ where $N = 25$, $s_D$ equals 0.253, the square root of 0.0642, (Table 2) and 2.58 is the t-value. These limits, ± 0.131 are indicated as a dotted line. Whenever the means for any particular period lie within these limits, it is concluded that there is no significant effect of time on the percent sucrose content of the beet pulp at the 1% level of significance. Upon examining Figure 2, it is evident that there is some variation from the assumed mean at all storage periods and that the greatest deviation of —0.128% is again for the 12-month period. This deviation, as well as the others, is not significant at the 1% level and thus, the deviations from the assumed mean of zero may be attributed to the variability in sampling and analyzing and not to time of storage.

**Summary**

Procedures for storing sugar beet pulp samples prior to sucrose analysis and for evaluating the results statistically have been developed. Fresh beet pulp samples weighing 26.0 grams each were sealed in small polyethylene bags, frozen immediately and kept in storage at —2° F for periods up to 32 months. A statistical study of the differences between the final and initial values indicated that the length of storage had no significant effect on the sucrose content of the pulp. Mechanical mixing of the pulp before sampling and a vigorous stirring of the slurry before filtration are recommended as added steps in the procedure for determining sucrose in beet pulp samples.

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# Combinations of Specific Fungicides for Sugar Beet Seed Treatment

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Seedling diseases of sugar beets have assumed greater importance during recent years, especially in certain areas of the Sacramento and San Joaquin Valleys in California. This increase may be due in part to adverse weather conditions but also in part to changes in the sequence of crops and an increase in late plantings.

If a lower labor requirement is to be achieved during stand reduction a uniform, low density population of healthy seedlings is required, whether singling is accomplished by machine or by simplified hand labor operations. The achievement of uniform, low density seedling populations has been retarded in northern California by the fact that during 1956 and particularly during 1958 seedling diseases of sugar beets were extremely severe as indicated by the acreage abandoned or replanted (Table 1). To reduce the loss of crop and the costs incidental to replanting, growers in general have tended to increase seeding rates. In favorable years such as 1959 and in fields little affected by seedling disease high seeding rates have resulted in stands of high density leading to increased difficulty of machine thinning or increased hand thinning costs.

**Table 1.—Replanted and Abandoned Acreage of Sugar Beets in Northern California because of Seedling Diseases, 1956-1958.[1]**

| | 1956 | 1957 | 1958 |
|---|---|---|---|
| | | Acres | |
| Area surveyed | 95,039 | 109,319 | 111,971 |
| Abandoned because of seedling disease | 3,019 | 1,677 | 7,837 |
| Replanted because of seedling disease | 4,540 | 4,507 | 11,112 |

[1] Compiled from data supplied by the agricultural staffs of Holly Sugar Corporation and Spreckels Sugar Company.

Because present seed treatment practices have not provided the protection required under conditions of severe infection, we have conducted extensive investigations under greenhouse house conditions to identify more efficient fungicides or more effective methods of seedling disease control.

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The problem is complicated by the fact that at least four different soil fungi cause seedling diseases of sugar beets in California. These organisms, *Pythium ultimum* Trow, *P. aphanidermatum* (Edson) Fitzp., *Rhizoctonia solani* Kuhn, and *Aphanomyces cochlioides* Drechs., differ in their abundance according to soil type, climatic conditions, season of planting, and previous cropping practices. Furthermore, these organisms usually occur in combinations rather than as simple infections by a single fungus.

As new fungicides have become available we have tested them in the laboratory and greenhouse against each of the seedling pathogens. From these trials we have identified a few fungicides that show high effectiveness against certain fungi but are, in some cases, so specific that they are not effective against others. With mixed fungus infections certain combination treatments appear especially promising.

Greenhouse trials from 1955 to 1957 showed that an experimental fungicide, Bayer 15080 (quinone oxime benzoyl hydrazone)[2] used as a seed treatment gave good protection of seedlings against *Pythium ultimum* but little or no protection against *Rhizoctonia solani*. Pentachloronitrobenzene (PCNB), on the other hand, protected seedlings against Rhizoctonia but not against Pythium. Neither fungicide, when used as a seed treatment, has proved effective against *Aphanomyces cochlioides*.

During the spring and summer of 1957 these two fungicides were evaluated alone and in combination in five field plantings in comparison with nontreated seed and with seed treated with Phygon (dichloronaphthoquinone or dichlone). These trials were located in northern California. The results are shown in Table 2.

In three of the five trials, Bayer 15080 resulted in significantly more seedlings than seed treated with Phygon. PCNB-treated seed did not improve stands in any of the trials and in several cases the stands from combination treatments were reduced below those from Phygon or Bayer 15080 used alone. These results indicated that Rhizoctonia was of minor importance in these fields and also suggested that PCNB, at the rate used (4 oz. of 75% PCNB per 100 lb. seed), was slightly phytotoxic.

In March, 1957, Dexon (P-dimethylaminobenzenediazo sodium sulfonate, Bayer 22555) was offered by the manufacturer for testing as a soil fungicide. Greenhouse trials disclosed that this

[2] Frohberger, P. E. 1956. Untersuchungen uber die Wirkung von Chinonoximbenzoylhydrazon gegen Keimlingskrankheiten verschiedener Kulturpflanzen. Phytopathologische Zeitschrift 27:427-455. (English trans. Hofchen-Briefe IX:253-279.)

Table 2.—The Effect of Seed Treatment on Stands of Sugar Beets. Values are Seedlings per Ten Feet of Row. Results of 1957 Field Trials.

| Seed Treatment[1] Material | Dosage Oz/100 Lb. | Trial Number 1 | 2 | 3 | 4 | 5 | Avg. of 5 Trials |
|---|---|---|---|---|---|---|---|
| | | Treatment means | | | | | |
| None | .... | 81 | 70 | 23 | 47 | 70 | 58 |
| PCNB | 4 | 78 | 83 | 18 | 57 | 59 | 59 |
| Phygon XL | 4 | 131 | 106 | 27 | 55 | 82 | 80 |
| Phygon XL + PCNB | 4 4 | 115 | 96 | 29 | 53 | 78 | 74 |
| Bayer 15080 | 2 | 145 | 120 | 36 | 82 | 86 | 94 |
| Bayer 15080 + PCNB | 2 4 | 133 | 102 | 31 | 65 | 79 | 82 |
| Sign. Diff. (19:1) | | 13 | 17 | 9 | 11 | 10 | .... |
| Interaction | | n.s. | [2] | n.s. | [3] | n.s. | .... |

[1] PCNB - 75% pentachloronitrobenzene (Terraclor); Phygon - 50% dichloronapthoquinone (dichlone); Bayer 15080 - 50% quinone oxime benzoyl hydrazone (Cerenox in Europe).

[2] [3] Indicates significant effects at the 5% and 1% levels, respectively.

material used as a seed treatment was extremely effective against *Pythium ultimum*, moderately effective against *P. aphanidermatum* and *Aphanomyces cochlioides*, but ineffective against *Rhizoctonia solani*. However, as a seed treatment Dexon proved to be more effective against *A. cochlioides* than any other fungicide tested although satisfactory protection was not obtained in severely infested heavy soils. Combination treatments of Dexon and PCNB were especially effective in soils containing both *R. solani* and *P. ultimum*.

In 1958, with the cooperation of beet sugar companies, farm advisors and growers, 19 field trials were completed in which standard commercial fungicides were compared with three candidate fungicides used alone and in combination. Twelve of these trials were located in northern California (trials 1 through 12, Tables 3 and 4). Seven were located in other states by the American Crystal Sugar Company as follows: two in Colorado (trials 13 and 14, Table 4), one in Iowa (trial 15, Table 4) and four in Minnesota (trials 16 through 19, Table 4). Individual plots were small consisting of two or four rows 50 feet long planted with a commercial seeder or, in trials 11 through 19, of 120 seeds dropped in 10 feet of row by a special plot planter.

Table 3.—The Effect of Seed Treatments on Stands of Sugar Beet Seedlings, 1958 Trials, With Phygon the Standard Fungicide. Values are Seedlings per Ten Feet of Row.

| Seed Treatment[1] | | Trial Number | | | | | | | | | | Avg. of All Ten Trials | Avg. of Four Trials[3] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Materials | Oz. per 100 Lb. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | |
| **Treatment Means[2]** | | | | | | | | | | | | | |
| None | — | 74 | 55 | 46 | 20 | 45 | 81 | 38 | 47 | 26 | 55 | 49 | 50 |
| PCNB | 2 | 102 | 60 | 55 | 27 | 61 | 69 | 37 | 54 | 37 | 57 | 56 | 54 |
| Phygon | 6 | 101 | 80 | 44 | 42 | 89 | 85 | 52 | 64 | 41 | 85 | 68 | 74 |
| Phygon + PCNB | 6 + 2 | 94 | 75 | 47 | 41 | 85 | 82 | 31 | 54 | 52 | 88 | 65 | 70 |
| B-15080 | 2 | 103 | 79 | 50 | 64 | 83 | 96 | 42 | 54 | 43 | 82 | 70 | 80 |
| B-15080 + PCNB | 2 + 2 | 117 | 67 | 46 | 66 | 92 | 86 | 43 | 66 | 49 | 101 | 73 | 78 |
| Dexon | 2 | 91 | 78 | 61 | 68 | 92 | 95 | 50 | 65 | 34 | 81 | 72 | 83 |
| Dexon + PCNB | 2 + 2 | 128 | 83 | 54 | 65 | 89 | 101 | 43 | 63 | 52 | 87 | 77 | 85 |
| LSD (5%) | | n.s. | 18 | n.s. | 12 | 16 | 11 | n.s. | 8 | n.s. | 19 | .... | 8 |
| **Average Effect of PCNB[4]** | | | | | | | | | | | | | |
| Without PCNB | | 92 | 73 | 50 | 48 | 78 | 90 | 46 | 58 | 36 | 76 | 64 | 72 |
| With PCNB | | 110 | 71 | 51 | 50 | 82 | 84 | 39 | 59 | 48 | 83 | 68 | 72 |
| LSD (5%) | | 16 | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | 8 | n.s. | n.s. | n.s. |
| **Average Effect of Other Fungicides[4]** | | | | | | | | | | | | | |
| None | | 88 | 57 | 51 | 24 | 53 | 75 | 38 | 50 | 32 | 56 | 52 | 52 |
| Phygon | | 98 | 77 | 45 | 41 | 87 | 84 | 42 | 59 | 46 | 86 | 67 | 72 |
| B-15080 | | 110 | 73 | 48 | 65 | 87 | 91 | 42 | 60 | 46 | 92 | 71 | 79 |
| Dexon | | 109 | 81 | 58 | 67 | 90 | 98 | 47 | 64 | 43 | 84 | 74 | 84 |
| LSD (5%) | | n.s. | 13 | n.s. | 9 | 11 | 8 | n.s. | 6 | 12 | 13 | .... | 5 |

[1] PCNB—75% pentachloronitrobenzene; Phygon—50% dichloronaphthoquinone; Bayer 15080—50% quinone oxime benzoyl hydrazone; Dexon (Bayer 22555)—85% P-dimethylaminobenzenediazo sodium sulfonate.
[2] Interaction of PCNB with non-treated seed and the other fungicides was not significant at the 5% level in any of the trials.
[3] Data for trials 2, 4, 5 and 6 were combined on the basis of having homogeneous error variances.
[4] Averages of all plots having seeds treated with the fungicide indicated.

Table 4.—The Effect of Seed Treatments on Stands of Sugar Beet Seedlings, 1958 Trials, with Captan as the Standard Fungicide.

[4] Averages of all plots having seeds treated with the fungicide indicated.

Table 4.—The Effect of Seed Treatments on Stands of Sugar Beet Seedlings, 1958 Trials, with Captan as the Standard Fungicide. Values are Seedlings per Ten Feet of Row.

| Seed Treatment[1] | | Trial Number | | | | | | | | | Average of All Trials[3] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Materials | Oz. per 100 Lb. | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | |
| | | | | | | Treatment Means[2] | | | | | |
| None | .... | 19 | 66 | 57 | 73 | 51 | 46 | 44 | 46 | 32 | 48 |
| PCNB | 2 | 19 | 65 | 63 | 76 | 50 | 48 | 51 | 42 | 42 | 50 |
| Captan | 10 | 35 | 71 | 116 | 97 | 63 | 60 | 49 | 62 | 60 | 67 |
| Captan + PCNB | 10 + 2 | 41 | 76 | 119 | 111 | 65 | 61 | 53 | 60 | 62 | 71 |
| B-15080 | 2 | 50 | 97 | 118 | 94 | 59 | 52 | 63 | 44 | 57 | 70 |
| B-15080 + PCNB | 2 + 2 | 44 | 76 | 120 | 92 | 65 | 55 | 54 | 56 | 61 | 69 |
| Dexon | 2 | 45 | 69 | 128 | 105 | 67 | 63 | 56 | 55 | 70 | 73 |
| Dexon + PCNB | 2 + 2 | 40 | 94 | 140 | 108 | 71 | 57 | 60 | 62 | 66 | 77 |
| LSD (5%) | | 11 | 17 | 12 | 12 | 11 | 11 | 10 | 12 | 13 | 4 |
| | | | | | | Average Effect of PCNB[4] | | | | | |
| Without PCNB | | 38 | 76 | 105 | 92 | 59 | 55 | 53 | 52 | 55 | 64 |
| With PCNB | | 36 | 78 | 110 | 97 | 63 | 55 | 55 | 55 | 58 | 67 |
| LSD (5%) | | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | 2 |
| | | | | | | Average Effect of Other Fungicides[4] | | | | | |
| None | | 19 | 66 | 60 | 74 | 50 | 47 | 48 | 44 | 37 | 49 |
| Captan | | 38 | 74 | 117 | 104 | 62 | 60 | 51 | 61 | 61 | 69 |
| B-15080 | | 47 | 87 | 119 | 93 | 62 | 53 | 59 | 50 | 59 | 69 |
| Dexon | | 43 | 81 | 134 | 107 | 69 | 60 | 58 | 59 | 68 | 75 |
| LSD (5%) | | 8 | 12 | 9 | 8 | 8 | 8 | 7 | 8 | 9 | 3 |

[1] Captan is 50% N-trichloromethylmercapto-4-cyclohexene-1, 2-dicarboximide. See footnote [1] Table 3 for chemical composition of other compounds.
[2] The interaction of PCNB with non-treated seed and the other compounds was not significant at the 5% level in any of the trials.
[3] All trials had similar error variances and were combined for analysis.
[4] Averages of all plots having seeds treated with the fungicide indicated.

## Results, 1958 Trials

*Comparisons with Phygon*

The seedling counts from trials 1 through 10 in which Phygon was used as the standard seed treatment are presented in Table 3. There are wide differences in error variances and consequently all trials could not be combined in a single analysis. However, four of the trials, numbers 2, 4, 5, and 6, have homogeneous error variances and were combined for analysis following the method of Roessler and Leach[3] (last column, Table 3).

The results of the individual trials and the combined series show that PCNB used alone was not a satisfactory treatment. All other treatments definitely improved stands over those resulting from nontreated seed in most of the trials.

The average effect of PCNB indicates a significant improvement in only trials 1 and 9. The difference in trial 10 is nearly significant at the 5 percent level. Judging from greenhouse results we can assume that only in these trials was *Rhizoctonia solani* important in reducing seedling stand.

Considering the average effect of the other fungicides it is clear that treatment with Phygon significantly improved stands over nontreated seeds in seven of the ten trials. As in the 1957 trials, Bayer 15080 was equal to or more effective than Phygon. Dexon gave higher average stands than Phygon in eight of the ten trials and higher than Bayer 15080 in seven of the trials, although it did not differ significantly from Bayer 15080 in any of the individual trials. On the basis of the average of all of the trials, as well as with the homogeneous series, Dexon was significantly better than Phygon and appeared to give better protection than Bayer 15080 although the difference was just significant at the 5 percent level.

*Comparisons with Captan*

The results of the trials in which Captan was used as a standard fungicide are given in Table 4. Because of remarkable similarity of error variances it was possible to combine all nine trials in a single analysis. In this analysis, when the average of all plots in which seed was treated with PCNB is compared with the average of those where PCNB was not used a small but significant increase due to PCNB was observed. This effect could not be measured at the 5 percent level in any of the individual trials. This indicates that, while Rhizoctonia was not a major factor in any of these trials, this fungus did cause the loss of some

[3] Roessler, E. B., and L. D. Leach. 1944. Analysis of combined data for identical replicated experiments. Proc. Amer. Soc. Hort. Sci. 44: 323-328.

seedlings and that this effect could only be measured at the 5 percent level of significance by many replications.

A comparison of the average effects of the other fungicides for all the trials shows that all three materials improved emergence over that from nontreated seed. Captan and Bayer 15080 resulted in 41 percent more seedlings than was obtained from nontreated seed, while Dexon gave a 52 percent increase. The improvement in stand resulting from seed treated with Dexon compared to the other two materials is significant at the 1 percent level.

Field trials for 1959 were designed to compare Dexon and Phygon when each compound was used alone and in combination with PCNB. Plots of each trial consisted of four-row strips through a commercial field. Nontreated seed was not included because of the large size of the plots and the danger of stand deficiencies from nontreated seed. Seeds were planted with the seeder used by the grower. A randomized complete block design was used for each trial with six replications. Treatments were evaluated by counts of healthy seedlings soon after emergence and again just before thinning. Counts were made on ten feet of all four rows of each plot at two different locations in the field.

## Results, 1959 Trials

The seedling stands resulting from the treatments in nine trials are given in Table 5.

Considering the individual trials, interactions significant at the 5 percent level occurred at two locations (trials 4 and 9). In both cases interaction was due to stand increases associated with the addition of PCNB to Dexon in contrast to no increase when PCNB was added to Phygon. The same tendency was noted in several of the 1958 trials (Table 3) but the apparent interaction was not significant at the 5 per cent level in any of the trials of that year.

There were significant effects of PCNB in two trials where interactions were not significant. In one (trial 3) PCNB improved stand; in the other it decreased stand (trial 7). In the latter trial there was a significant improvement due to Dexon; this effect also occurred in trial number 8.

On the basis of homogeneity of error variances, it was possible to combine the trials in two groups, one involving seven locations, the other, two. A summary of these analyses is given in the last two columns of Table 5.

The combined results from seven locations show a significant interaction of PCNB with Phygon and Dexon. PCNB combined

Table 5.—The Effect of Seed Treatment on Stands of Sugar Beet Seedlings, 1959 Trials. Values Are Seedlings per Ten Feet of Row Just Prior to Thinning.

| Seed Treatment[1] | | Trial Number | | | | | | | | | Avg. of Trials 1 to 7[2] | Avg. of Trials 8 and 9[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Materials | Oz. per 100 Lb. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | |
| **Treatment Means** | | | | | | | | | | | | |
| Phygon | 6 | 66 | 73 | 78 | 134 | 72 | 80 | 115 | 124 | 155 | 89 | 138 |
| Phygon + PCNB | 6 + 2 | 63 | 72 | 86 | 130 | 65 | 78 | 104 | 116 | 158 | 86 | 135 |
| Dexon | 2 | 67 | 66 | 75 | 127 | 74 | 79 | 135 | 155 | 151 | 89 | 153 |
| Dexon + PCNB | 2 + 2 | 67 | 68 | 83 | 138 | 79 | 83 | 124 | 145 | 172 | 92 | 157 |
| LSD (5%) | | n.s. | n.s. | n.s. | 10 | 15 | n.s. | 15 | 18 | 21 | 4 | 14 |
| Interaction | | n.s. | n.s. | n.s. | [4] | n.s. | n.s. | n.s. | n.s. | [4] | [4] | n.s. |
| **Average Effect of PCNB[3]** | | | | | | | | | | | | |
| Without PCNB | | 67 | 69 | 75 | 131 | 73 | 80 | 125 | 140 | 153 | 89 | 146 |
| with PCNB | | 65 | 70 | 84[1] | 134 | 72 | 80 | 114[1] | 131 | 165 | 89 | 146 |
| **Average Effect of Phygon and Dexon[3]** | | | | | | | | | | | | |
| Phygon | | 64 | 72 | 81 | 132 | 68 | 79 | 109 | 120 | 156 | 88 | 136 |
| Dexon | | 67 | 67 | 79 | 132 | 76 | 81 | 129[5] | 150[5] | 161 | 91[4] | 155[5] |

[1] Dexon is 70% P-dimethylaminobenzenediazo sodium sulfonate. See footnote [1] Table 3 for chemical composition of other fungicides.
[2] Combined for analysis on the basis of similar error variances.
[3] Averages of all plots with seeds treated with the fungicides indicated.
[4] [5] Indicates significant effects at the 5% and 1% levels, respectively.

with Dexon tended to improve stand, but in combination with Phygon no improvement and possibly a reduction in stand was observed. When each was used alone, Dexon and Phygon produced equal results. Dexon in combination with PCNB resulted in a stand which was significantly greater than that resulting from the combination of Phygon and PCNB. In both combined series there was a significant over-all effect of improved stands with Dexon compared to Phygon.

## Summary and Conclusions

During 1957-59 thirty-four field trials were conducted to evaluate pentachloronitrobenzene (PCNB), p-dimethylaminobenzenediazo sodium sulfonate (Dexon) and quinone oxime benzoyl hydrazone (Bayer 15080) as seed treatments used alone or in combinations. Fungicides in commercial use were included as standards.

Previous to and concurrent with the field trials numerous greenhouse trials were conducted to identify the effects of several organic compounds used as seed treatments for controlling seedling disease caused by specific pathogens. Results of the greenhouse trials are briefly iscussed.

The results of the field trials indicated that:

1. PCNB used alone had little or no advantage over non-treated seed.

2. PCNB added to Phygon did not increase and in certain instances decreased stands.

3. Dexon at a relatively low dosage rate was superior to Phygon and Captan at higher dosage rates.

4. On the average Dexon was superior to Bayer 15080.

5. The combination of Dexon and PCNB in some fields resulted in improved stands compared to stands from seed treated only with Dexon.

## Acknowledgment

The field trials were a cooperative effort between sugar companies, growers and the University of California. The following organizations and individuals were especially helpful in conducting the trials. American Crystal Sugar Company, R. E. Finkner and Norman Lawlor, Jr.; Holly Sugar Corporation, John Hoff; Spreckels Sugar Company, Lauren Burtch; University of California Farm Advisors, R. S. Baskett, S. P. Carlson, R. C. Harkens, and M. D. Morse.

# Minutes of the Eleventh General Meeting of the American Society of Sugar Beet Technologists

The business session of the Eleventh General Meeting of the American Society of Sugar Beet Technologists was called to order by the Society's President, Mr. Harvey P. H. Johnson, at 11:10 a.m. on Thursday, February 4, 1960, in the Convention Center, Hotel, Utah Motor Lodge, Salt Lake City, Utah.

Mr. Johnson served as chairman of the meeting and announced that the purpose of this meeting was to hear committee reports, the report of the secretary, the report of the treasurer and to transact what other business as may be necessary and appropriate at this meeting.

The chairman called for the reading of the minutes of the Tenth General Meeting held in Detroit, Michigan, February 4, 1958. Upon motion made, seconded and unanimously carried, the reading of the minutes was dispensed with.

The chairman then acknowledged the efforts by many Society members and contributors who have developed plans and completed details which have made this Eleventh General Meeting the most successful yet held by our Society. He specifically acknowledged the efforts of the Program Chairman, his Section Chairmen, the Local Arrangements Chairman, the speakers at our General Sessions and the sectional meetings, the Chamber of Commerce of the city of Salt Lake City, Utah, the Western Beet Sugar Producers, Inc., the Officers and Advisory Council of the Society, the Hotel Utah, The Silver Engineering Works, The Amalgamated Sugar Company and the Utah-Idaho Sugar Company.

Upon the request of the Chairman, the Secretary read the Report of the Secretary. Upon motion made, seconded and unanimously carried, the Report of the Secretary was accepted, ordered placed on file, and made a part of these minutes.

## Report of the Secretary

The membership of the Society at the close of the biennium 1958-1959 was 578 individuals and companies. Members reside in 34 states of the United States and 18 foreign countries and possessions. Membership for the biennium just completed showed an increase over the previous biennium by 32 members. A list of states and countries showing the number of members in each is attached to and made a part of this report.

More than 800 copies of the JOURNAL OF THE AMERICAN SOCIETY OF SUGAR BEET TECHNOLOGISTS are mailed each printing. They are being sent to 35 states and 33 foreign countries. Correspondence has been conducted with an additional 10 to 15 countries, many of which are behind the iron curtain. Distribution of our Journal and research results are restricted to friendly nations in compliance with the general restrictions set forth by the United States Department of Agriculture.

An office for the secretary-treasurer has again been provided the Society by the Beet Sugar Development Foundation. The staff of the Foundation conducts the duties consistent with the normal operations of such an office. In addition, the staff edits and publishes the Journal at no cost to the Society other than direct publication costs and direct office expenses.

**Memberships by States and Countries—1958-1959**

| | |
|---|---|
| Washington, D. C. | 3 |
| Arizona | 3 |
| California | 132 |
| Colorado | 104 |
| Connecticut | 2 |
| Delaware | 3 |
| Florida | 1 |
| Georgia | 1 |
| Hawaii | 1 |
| Idaho | 17 |
| Illinois | 23 |
| Iowa | 7 |
| Kansas | 2 |
| Louisiana | 1 |
| Maryland | 5 |
| Massachusetts | 2 |
| Michigan | 37 |
| Minnesota | 10 |
| Missouri | 1 |
| Montana | 12 |
| Nebraska | 13 |
| New Jersey | 1 |
| New Mexico | 1 |
| New York | 12 |
| North Carolina | 1 |
| Ohio | 18 |
| Oklahoma | 1 |
| Oregon | 6 |
| Pennsylvania | 1 |
| South Dakota | 3 |
| Utah | 45 |
| Washington | 8 |
| Wisconsin | 6 |
| Wyoming | 8 |

**Foreign Countries**

| | |
|---|---|
| Canada | 47 |
| England | 5 |
| Spain | 2 |
| Denmark | 6 |
| Belgium | 1 |
| Ireland | 2 |
| Netherlands | 3 |
| Pakistan | 1 |
| Australia | 1 |
| Iran | 2 |
| Nigeria | 1 |
| Israel | 1 |
| Germany | 2 |
| Syria | 1 |
| Sweden | 2 |
| Uruguay | 1 |
| Chile | 1 |
| Japan | 2 |
| Total | 572 |
| Company Members | 6 |
| | 578 |

The chairman then requested that the Report of the Treasurer be read. The Treasurer then reviewed receipts and disbursements for the biennium January 1958 through December 31, 1959. Upon motion made, seconded and unanimously carried, the Report of the Treasurer was accepted, ordered placed on file and made a part of these minutes.

## Report of the Treasurer

### Balance Sheet

**December 31, 1959**

| | Debit | Credit |
|---|---|---|
| Cash Balance, January 1, 1958 | | $ 7,959.31 |
| Publications | $ 8,566.70 | 2,688.97 |
| Postage | 996.29 | 27.33 |
| Meeting Expense | 986.59 | |
| Ledger Accounts | 1,812.10 | 1,809.05 |
| Miscellaneous | 242.52 | 5,600.55 |
| (A) Fort Collins Federal Savings & Loan | 5,359.10 | |
| Membership Dues | | 2,988.94 |
| Office Expense | 1,529.62 | |
| Reprints | 948.91 | 1,221.00 |
| Registration Fees | | 1,344.00 |
| Banquet | | 125.45 |
| Interest Earned— | | |
| Fort Collins Federal Savings & Loan | | 359.10 |
| Cash Balance, December 31, 1959 | 3,681.87 | |
| | $24,123.70 | $24,123.70 |

The chairman then reported that he had appointed a committee consisting of Dr. H. E. Brewbaker, chairman, B. E. Easton, and Dr. R. T. Johnson, to study and report on the possibility of arranging a joint meeting schedule between the American Society of Sugar Beet Technologists and the Institut International de Recherches Betteravieres. A report by this committee was made and discussion from the floor was heard. Upon motion by Dr. Brewbaker, seconded and unanimously carried, the report as accepted becomes a part of these minutes.

1. The American Society of Sugar Beet Technologists, at its Eleventh General Meeting, hereby records its intentions to favor some form of joint meetings at more or less regular intervals with the Institut International de Recherches Betteravieres.
2. The assembly suggests that the first of such meetings be held in England in 1961 at a time and place specified by the Institut International de Recherches Betteravieres: the second meeting to be held in the United States or Canada in 1964 at a time and a place specified by the American Society of Sugar Beet Technologists; similar meetings to be continued on a three or five-year rotating basis.
3. Joint meetings of such nature would not constitute any form of integration of the two Societies.
4. Any necessary limitation of numbers who might attend any joint meeting would be the prerogative of the host Society.

5. The Executive Board of the American Society of Sugar Beet Technologists is herewith empowered to make any and all necessary arrangements to activate this program of joint meetings.

The secretary was instructed by the chairman to transmit the wishes of this Society as explained in the report to the secretary of the I.I.R.B. for consideration at its Seventh General Meeting.

Proposed revisions in the Constitution and Bylaws were reported by committee chairman, Guy Manuel. The Secretary was instructed to send a mail ballot to each member for vote.

The chairman announced that the meeting would accept invitations for the site of our Twelfth General Meeting. Mr. P. B. Smith, speaking on and in behalf of the city of Denver, invited the American Society of Sugar Beet Technologists to hold its Twelfth General Meeting in Denver in 1961. On motion made, seconded and unanimously carried, Denver, Colorado, was selected as the site for the Twelfth General Meeting of the Society.

It was then reported by the chairman that a Tally Committee had been appointed to determine the elected officers of the Society for the biennium 1960-61. He announced that the report of the Tally Committee would be made at the banquet. The newly elected Executive Committee and Advisory Council are listed below:

**Executive Committee**

President ..... Dewey Stewart
Vice President ..... J. C. Keane
Secretary-Treasurer ..... James H. Fischer
Immediate Past President ..... H. P. H. Johnson

**Advisory Council**

West Coast:
C. W. Bennett
Sam C. Campbell

Intermountain
Harry Elcock
Bion Tolman

Eastern Slope
Ralph Finkner
LeRoy Powers
Ralph Wood

Eastern United States
Mark R. Berrett
Dave Sunderland

Western Canada
J. G. Snow

Eastern Canada
Charles Broadwell

At Large
Guy Rorabaugh
H. M. Tysdal

There being no further business, the meeting was declared adjourned at 11:45 a.m.

## *Forty Year Veteran Awards*

Harold D. Burk, Great Western Sugar Company

Robert E. Burton, Layton Sugar Company

Charles M. Crabtree, Franklin County Sugar Company

E. H. Hungerford, Great Western Sugar Company

Vernal Jensen, Amalgamated Sugar Company

John C. Keane, Utah-Idaho Sugar Company

John J. Landysheff, (Retired), Canadian Sugar Factories, Ltd.

George W. Miles, Sr., (Retired), Holly Sugar Corporation

Norman J. Muscavitch, Great Western Sugar Company

O. S. Newsom, Holly Sugar Corporation

Donald O. North, Monitor Sugar Division, Robert Gage Coal Company

W. J. O'Bryant, (Retired), Utah-Idaho Sugar Company

Harold R. Olsen, Franklin County Sugar Company

Ira A. Resch, Spreckels Sugar Company

Paul K. Smith, Franklin County Sugar Company

Frank R. Taylor, Canadian Sugar Factories, Ltd.

T. A. Weir, Holly Sugar Corporation

# *Meritorious Service Award*

***These awards were presented at the Eleventh General Meeting to those who have been outstanding in promoting the objectives of this organization and who have been active in its affairs. The Society hereby acknowledges the important role each has played.***

## ROY BAINER

*Roy Bainer was born near Ottawa, Kansas, in 1902. Following his grade school education in Amarillo, Texas, and Topeka, Kansas, he operated a wheat farm near Scott City, Kansas, between 1918 and 1924. During this period, he also worked winters for two companies manufacturing gas engines and served as a field service man during summers for a tractor company at Scott City, Kansas. He received a B.S. degree in Agricultural Engineering at Kansas State in 1926 and a M.S. degree from the same college in 1929. He served as an instructor in agricultural engineering at Kansas State between 1926 and 1929 whereupon he moved to the University of California, Davis, California. He has served the University of California as assistant professor, assistant agricultural engineer, professor of agricultural engineering and in 1947 became chairman of the Department of Agricultural Engineering. In 1952 he was appointed assistant dean of engineering, University of California, Davis, Berkeley, and Los Angeles campuses. He has served as a consultant to the British Minister of Agriculture, to the army of occupation in Japan, and as codirector of a mechanization center in Chile. His inventions include processing equipment for segmenting and decorticating sugar beet seed. He has received the highest honors bestowed by the American Society of Agricultural Engineers by his election as its president and as recipient of the McCormick Medal in 1948. He is a member of numerous professional societies and has been the author and coauthor of two books and many technical papers and bulletins. He has been a member of The American Society of Sugar Beet Technologists since 1940, has been chairman of sections, sessions, and has served on numerous committees.*

## VERNAL JENSEN

*Vernal Jensen was born in Providence, Utah, on March 8, 1896. He was reared on a farm in Cache Valley, Utah, and attended the Utah State University. His college education was interrupted while serving with the U. S. Army during World War I and 18 months of this time were spent overseas. Following military service, he returned to the Utah State University and*

*completed his academic schooling, majoring in Chemistry. Although he had worked part time with The Amalgamated Sugar Company as early as October 1916, he commenced on a full-time basis with his company in 1920 as assistant chemist in the old Smithfield, Utah, plant. He was subsequently advanced to chief chemist and in 1930, he began working during the summer months in agricultural research, particularly devoting his efforts to the early development of curly-top resistant varieties of sugar beets. In 1934, he was transferred from the operating department to agricultural research as director of sugar beet development work. Vern has devoted many years to the improvement of the interrelations in the beet sugar industry. He has served ten years as a director of the Beet Sugar Development Foundation and, in the past, has served as its president and vice president. He has been a member of the American Society of Sugar Beet Technologists since its first meeting; has served on the Society's nominating committee; its awards committee; on the local arrangements committee; the program committee; has been elected several times to the advisory council; and has most recently served as the Society's vice president during the biennium 1958-59.*

## JOHN C. KEANE

*John C. Keane was born at Pine Island, Minnesota, on August 18, 1897. His education includes a B.A. in Chemistry from Loras College, Debuque, Iowa, and post graduate work at Georgetown, University of Washington, D. C. His employment with the beet sugar industry commenced with the Utah-Idaho Sugar Company, October 1919 at Garland, Utah, as assistant chemist. In October 1920 he was made chief chemist at Sugar City, Idaho, and in August 1923 became assistant factory superintendent. For six-month periods from January to July in 1923 and 1924, he was on leave of absence from the Utah-Idaho Sugar Company and on temporary appointments for Bureau of Chemistry, U. S. Department of Agriculture, Washington, D. C. In 1925 he took a permanent position with the Carbohydrate Division, Bureau of Chemistry, U. S. Department of Agriculture and was headquartered in Washington, D. C. During his assignment with the U. S. Department of Agriculture, he worked on problems of both cane and beet sugar. In April of 1937, he resigned from government service and resumed employment with the Utah-Idaho Sugar Company as assistant general superintendent. In March of 1943, he was promoted to general superintendent and became vice president and general superintendent in April 1959. Jack*

*has been on the advisory committee of the Sugar Research Foundation, Incorporated, since its inception, a member of the Sugar Research and Marketing Advisory Committee of the U. S. Department of Agriculture since October 1956, a member of the Beet Sugar Process Advisory Committee of the Beet Sugar Development Foundation for the Western Regional Laboratory, and many others. He has been a member of the American Society of Sugar Beet Technologists since 1938, has served on its resolutions committee, advisory council, has been chairman of the chemistry and factory operations section, has served on the awards committee, and on the nominating committee.*

## R. A. McGINNIS

*R. A. McGinnis was born in Douglas, Arizona, December 20, 1903. He was graduated from the University of California in 1925 with a B.A. in English. For a few years after graduation he was with the movie industry particularly in the film laboratories. This association turned his interests to the field of chemistry whereupon he returned to the University of California in pursuit of an advanced degree. In 1935 he was awarded the Ph.D. in Chemistry from the University of California and subsequently joined the staff of the Western Sugar Refinery as a research chemist. In 1939 he started his employment with the Spreckels Sugar Company as head research chemist. He was advanced to his present position of general chemist and director of chemical research in 1954. He has specialized as a research chemist in work on first carbonation process and on color and turbidity measurements of white sugar solutions. He is editor and author of the book "Beet Sugar Technology," and has authored many papers in the field of beet sugar technology. He has been chairman of numerous committees and advisory committees designed to further improved technology and standardization of methods and analyses. He has been a member of the American Society of Sugar Beet Technologists since 1948, has served on its constitution and bylaws committee, its nominating committee, and its editorial and review board.*

## LeROY POWERS

*LeRoy Powers was born in 1902 at Sheldon, Iowa, and was reared on an irrigated farm on the Huntley Project near Billings, Montana. Following his graduation from high school in 1920, he entered Montana State College where he graduated in 1924 with a B.S. in Agronomy. He earned his M.S. degree in Plant Breeding in 1926 from Washington State College and was awarded*

*the Ph.D. in Plant Genetics from the University of Minnesota in 1931. In July of 1926 he was employed as assistant to the superintendent, Huntley Experimental Farm, Huntley, Montana, and in November of that year became assistant agronomist at Montana State College at Bozeman. From July 1930 to July 1935 he was assistant professor and associate professor, University of Minnesota in Minneapolis. From here, he moved to Cheyenne, Wyoming, where he became senior geneticist and principal geneticist at the Cheyenne Horticultural Field Station of the U. S. Department of Agriculture. From July 1942 to January 1945 he was assigned to the Special Guayule Rubber Project, U. S. Department of Agriculture, Salinas, California, as principal geneticist. For the next year and a half he was plant breeder with the Spreckels Sugar Company at Spreckels, California. In June of 1946 he returned to the Cheyenne Horticultural Field Station of the U. S. Department of Agriculture at Cheyenne, Wyoming, as principal geneticist. In July of 1954 he was transferred to the Sugar Beet Section of the Agricultural Service of the USDA at Fort Collins, Colorado, as principal geneticist, the position he currently holds. He has received numerous awards of distinction in his profession and has been recognized by the U. S. Department of Agriculture for his contributions to the agricultural sciences.*

## HELEN SAVITSKY

*Helen Savitsky was born in Russia in 1901. She received her Agronomy Degree at the University of Agriculture, Charkov, in 1924. She graduated from the College of Genetics and Plant Breeding at Charkov in 1926 and earned a Master of Science Degree in Biology, Cytology at Moscow in 1937. In 1940 the Ph.D. in Biology, Cytogenetics from the University of Leningrad was awarded her. She started her work in cytogenetics and breeding of sugar beets in 1927 at the Belaja Zerkov Breeding Station and was appointed junior specialist in cytology, embryology. The next year she was promoted to senior specialist and chief of the laboratory of cytology at the breeding station. In 1930 she became chief, Cytological Laboratory, Research Institute for Sugar Industry in Kiev. In 1941 she became chief of Cytological Laboratory and of Labor for Oil Crops, Ukrainian Institute for Plant Breeding in Kiev. Two years later at Posen, Poland, she was a cytologist at the Institute of Botany at the University of Posen. In 1945 she became a cytogeneticist with the University of Halle, Halle/Sale, Germany, and the next year a research collaborator with the Sugar Beet Breeding Firm Nordhausen in Germany.*

*In 1947 she was assigned as a professor of anatomy, cytology, and embryology with the Ukrainian Technical Institute at Regensburg, Germany. Later that year she came to the United States and began working with the Curly Top Resistance Breeding Committee at Salt Lake City and as a collaborator with the U. S. Department of Agriculture. She is currently a cytogeneticist with the Beet Sugar Development Foundation in Salt Lake City and continues as a collaborator with the U. S. Department of Agriculture.*

## V. F. SAVITSKY

*V. F. Savitsky was born in Russia in 1902. He received his Agronomy degree at the University of Agriculture, Charkov, in 1923. He then attended the College for Genetics and Plant Breeding at Charkov graduating in 1926. In 1936 he earned a Master of Science Degree in Biology, Genetics at Moscow and in 1939 was awarded the Ph.D. in Biology, Genetics from the University of Leningrad. He started working with the breeding of sugar beets in 1923 at the Charkov Breeding Station and in 1925 became junior specialist at the breeding station in Belaja Zerkov. At this time he was also assistant professor in genetics, plant breeding, and statistics at the University of Agronomy, Belaja Zerkov. In 1928 he became senior specialist and chief of the laboratory of genetics at the breeding station. Between 1930 and 1941 he was professor of genetics, plant breeding, and statistics in the University of Agronomy in Belaja Zerkov and was chief of the laboratory of genetics and plant breeding for the Research Institute for Sugar Industry, Kiev. In 1941, he was the Director, Ukrainian Institute for Plant Breeding at Kiev and between 1943 and 1945, he was a geneticist with the Institute for Plant Breeding, University of Posen, Posen, Poland. In 1945, he became a geneticist with the University of Halle, Halle/Sale, Germany, and the next year, a research collaborator with the Sugar Beet Breeding Firm Nordhausen in Germany. In 1947 he was assigned a professor genetics and plant breeding with the Ukrainian Technical Institute at Regensburg, Germany. Later that year he came to the United States and commenced work at Salt Lake City with the Curly Top Resistance Breeding Committee and as a collaborator with the U. S. Department of Agriculture. He is presently a geneticist with the Beet Sugar Development Foundation in Salt Lake City and continues as a collaborator with the U. S. Department of Agriculture.*

## HAROLD F. SILVER

*Harold F. Silver was born in Salt Lake City on March 15, 1901. As a boy he worked in his father's shop, The Silver Brothers Iron Works, the first general machine shop in the state of Utah. He then attended the University of Utah and following graduation he received the assignment as chief engineer of the Ogden Iron Works Company of Ogden, Utah. In 1934, he became interested in the sugar beet industry and moved to Denver where he organized the Silver-Roberts Iron Works to build and develop sugar refining and handling equipment. He was vice president and general manager until 1940 when he purchased Roberts' interest and became the company's president. He was instrumental in the invention and development of a continuous diffusion process for the sugar industry and a continuous mining machine for the coal industry. In 1938, he organized a steel warehousing division called the Silver Steel Company. Both the Silver Steel Company and the Silver Engineering Works, Incorporated, continue to expand and better serve the needs of the beet sugar industry for improved equipment in its continuing efforts of modernization. Mr. Silver has been most generous with his time by sharing his leadership and business abilities with community, institutional, and social service projects. He has received a number of awards for his business and civic accomplishments such as the award of merit for business achievement in 1944 from the University of Colorado School of Business, the State Chamber's award for outstanding businessman in Colorado in 1951, and in 1957 the United Fund award for outstanding service. He is a director of the Denver Symphony Society, a Trustee of Denver University, is serving as president of the Denver Area Council, Boy Scouts of America, and a host of other activities of greater and lesser importance. He has been a member of the American Society of Sugar Beet Technologists since its beginning and has continued to be active in its affairs.*

## *In Memoriam*

H. R. Brookman, Los Angeles, California
Edgar B. Cole, Ogden, Utah
E. F. Ellingson, Salt Lake City, Utah
J. G. English, Brighton, Colorado
H. H. Feldstein, Cleveland, Ohio
M. A. Gallacher, Hamilton, Ohio
Kurt Grunwald, Bayport, Long Island, N. Y.
A. K. Logan, Alvarado, California
Ray Sharp, Sugar City, Colorado
Carl K. Sieland, Caro, Michigan
George P. Wright, Salinas, California